JPRS-USP-89-007
28 JUNE 1989

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JPRS Report

Science & Technology

USSR: Space

Science & Technology
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JPRS-USP-89-007 *28 June 1989*

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Cosmonauts Begin Preparing For Return

LD1404101189 Moscow TASS in English 0937 GMT 14 Apr 89

[Text] Moscow April 14 TASS—by a TASS correspondent reporting from Mission Control Center:

The cosmonauts Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov this week continued maintenance operations on board the orbital space complex Mir (Peace) as well as astrophysical and medical experiments.

In keeping with plans for their return to earth, the Soviet spacemen, in addition to routine daily exercises, have started training with the use of the pressurised spacesuit Chibis.

The crew are continuing studies into space astronomy covered by the international project Roentgen.

They conducted five sessions observing a powerful X-ray pulsar in the Taurus constellation.

Several series of visual observations and photography of Soviet territory are yet to be conducted. One of the objectives is to assess the pollution of the atmosphere above areas around industrial centres in the Ukraine, the Black-Earth Region and the Volga basin.

According to results of medical check-ups and reports from the orbit, the cosmonauts are in good health.

'Mir' Cosmonauts Conduct Medical Research

LD1804105189 Moscow TASS in English 1016 GMT 18 Apr 89

[Text] Moscow April 18 TASS—TASS correspondent reports from the Flight Control Center: the new workday of the crew aboard the orbital complex Mir began with the medical research conducted under the plan of preparations for a return to earth.

Today, Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov will be engaged in the scheduled maintenance work on onboard systems and equipment and in taking stock of the available expendable materials. Geophysical experiments and two-hour physical exercises are also planned for today.

Under the schedule of work with the Progress-41 tanker-transport vehicle, the cosmonauts are refueling the base module's tanks with oxidizer.

The Flight Control Center continues to monitor the flight of the orbital station Salyut-7 which has been operating in near-terrestrial space for seven years. In August 1986, it was switched to a higher orbit to conduct resource tests. Telemetry about the state of the station's onboard systems regularly comes in to the Flight Control Center for processing and analysis.

'Progress-41' Undocked From 'Mir'

LD2104163389 Moscow TASS in English 1624 GMT 21 Apr 89

[Text] Moscow April 21 TASS—By a TASS correspondent at the Ground Control Center:

The unmanned Progress-41 space freighter was jettisoned from the orbiting station Mir at 5:46 Moscow time today after all its supplies, including drinking water, fuel, an oxidising agent and hardware, were transferred to the station.

The supply craft's engines were earlier used to correct Mir's orbit.

The three cosmonauts on board the station—Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov—are continuing preparations for a return to earth.

Their program for the day has included replacing spent components of on-board systems, undergoing medical checks, training using a pneumatic vacuum suit Chibis, and staging several biological experiments.

The spacemen are feeling well.

'Mir' Cosmonauts To Return to Earth 27 April

LD2604112789 Moscow TASS in English 1122 GMT 26 Apr 89

[Text] Moscow April 26 TASS—By a TASS special correspondent reporting from Mission Control Center:

The Soviet cosmonauts Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov are completing work on board the orbital space complex Mir (peace) and are due to return to earth on April 27, at 6:58 Moscow time.

The crew are packing mission documentation, cassettes with cinema and still films, spectrograms and other research material in to the landing module of the Soyuz TM-7 spaceship.

They will also mothball some on-board systems in preparation for the complex's operation in the unmanned mode.

At the concluding stage of the flight, the crew carried out a series of biological experiments aimed at synthesising polyacrylamide gel required for upgrading the technology of purifying biologically active compounds in earth conditions.

The flight of the unmanned spacecraft Progress-41, which docked the orbital complex on April 21, has been ended. The craft entered the dense layers of the earth's atmosphere above the Pacific Ocean on April 25, at 16:02 Moscow time and disintegrated.

Cosmonauts Prepare for Return

LD2504102689 Moscow TASS in English 0902 GMT 25 Apr 89

[Text] Moscow April 25 TASS—TASS correspondent reporting from the Mission Control Center:

The space mission is drawing to an end as cosmonauts Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov crew carry out final scientific experiments, pack up materials with the results of experiments for their return to the earth.

In accordance with the plan for preparing cosmonauts for descent from the orbit they undergo medical tests, including during their training in the "Chibis" spacesuit.

Astrophysical research under the Roentgen international programme continues. On April 24 the cosmonauts registered radiation from the X-ray pulsar in the Hercules constellation. Today the telescopes of the orbital observatory will be trained at the X-ray source Cygnus X-1.

In the final stages of the flight the cosmonauts are carrying out a series of biological experiments to work out the technology of cultivating higher plants in zero-gravity. The Svetoblok-M and Rost-4M devices are used to study the development of wheat and arabidopsis genus, and orchids brought by the Soviet-French crew continue to grow in one of the onboard greenhouses.

Preparations for return to earth proceed normally. Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov feel well.

Cosmonauts Return; 'Mir' Mission Summarized

LD2704092989 Moscow TASS in English 0845 GMT 27 Apr 89

[Text] Moscow April 27 TASS—Cosmonauts Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov made a safe landing at 06:58 Moscow time on Thursday after completing work on board the Mir space research complex.

The landing capsule of the Soyuz TM-7 Spacecraft landed in an area 140 kilometers north-east of the city of Dzhezkazgan.

Cosmonauts Volkov, Krikalev and Polyakov are feeling well after the landing.

The Mir space station has been three years in orbit and has been manned for 880 days.

The station's modules, state of the art technology and the accumulated experience of maintenance account for the successful work of the space crews on board.

More than 200 experiments to grow volumetrical monocrystals of semi-conducting materials were conducted in conditions of weightlessness. Thus developed crystals are far better that similar materials manufactured on earth. The expediency of setting up experimental industrial production of semi-conductors has been proved.

Mir's electrophoretic installations were used to develop a method to purify and decompose biologically active substances. New drugs were developed and highly active substances for antibiotics for animal husbandry extracted. The technology of making high-quality protein monocrystals was developed as well as new production methods.

Different parts of earth were photographed and spectrometered under the program of studying mineral resources. The photographs from the Mir station and automatic space data help monitor global environmental processes in Kazakhstan and the Kalmyk Autonomous Republic, in the basins of the Aral and Caspian Seas and in other parts of the country. The data is also used to develop new methods of assessing the bioproductivity of seas and oceans, water and air pollution, salination and the saturation of lands near water reservoirs and canals.

The international roentgen observatory installed in the Kvant module provided unique information about the evolution of the emission spectra of a supernova in the Large Magellanic Cloud. Nuclear synthesis of chemical elements during a star explosion was studied for the first time in history. The acquired information about stellar processes is of great scientific importance. Photographs of parts of the celestial sphere made with the help of the Glazar telescope are being used to compile the first full star atlas in ultraviolet rays.

An effective medical support system enabled the cosmonauts to carry out four long-duration flights, including a record year-long space trip.

A wide program of neurophysiological, hematological and biochemical experiments and tests was carried out with direct participation of Doctor Valeriy Polyakov, who spent eight months on the Mir station.

New information on the functional state of the human body and working abilities of cosmonauts at different stages of the flight were obtained.

The results of these medical experiments and space diagnostic equipment are being widely used in health care.

Four international crews with cosmonauts from Syria, Bulgaria, Afghanistan and France worked on the Mir station on joint programmes drawn up by the Soviet Union and participating countries.

The results of joint cooperation in space will further promote scientific and technological progress in the Soviet Union and abroad and will serve to strengthen cooperation in the peaceful exploration of space.

The research program and experiments on board the Mir space station will be carried out automatically until another crew of cosmonauts arrives.

Details of Future 'Mir' Programs Outlined

LD2704074289 Moscow TASS in English 0659 GMT 27 Apr 89

[Text] Moscow April 27 TASS—The descent capsule of the Soyuz TM-7 spaceship landed in an area northeast of the city of Dzhezkazgan at 06:59 Moscow time on Thursday, bringing three Soviet cosmonauts back to earth from the space station Mir. Aleksandr Volkov, Sergey Krikalev and Valeriy Polyakov were the fourth resident crew on the orbiting platform since it was launched in February 1986.

Volkov and Krikalev were up there for five months, while Polyakov, who remained on Mir after flying there with a Soviet-Afghan team, spent nearly eight months in orbit.

The space station has six docking ports one of which was used in April 1987 to accomodate the astrophysics module Kvant (Quantum).

Together with a Soyuz TM transport vehicle and a Progress unmanned supply craft, the Mir facility is 33 meters long and weighs more than 50 tonnes.

It is to be further enlarged with two more modules—a service one and a technological one—this year.

All modules have the same approach control, active docking and power supply systems, while their scientific equipment and other on-board facilities differ depending on their mission. They weigh up to 20 tonnes each.

The service module has an extravehicular activity airlock and everything needed for work outside, including a manned maneuvering unit for a cosmonaut to move about in space.

It will also carry other equipment for Mir as well as fuel, water and food supplies and even a biological complex for mastering the technology of growing poultry in zero gravity.

The technological module will be used to launch the pilot-commercial production of extrapure semiconductor monocrystal materials which hold out much promise in diverse engineering fields.

According to Deputy Flight Director Viktor Blagov, it is planned to attach special platforms with scientific instruments on Mir's outer surface. It will be possible to aim the instruments on astronomical bodies and objects on earth without having to reorient the entire station, as has to be done now.

In addition, it will be possible to control the instruments from earth.

Mir has remained continuously manned since February 1987 through crew change-overs. It was originally planned that two other Soviet cosmonauts, Aleksandr Viktorenko and Aleksandr Balandin, would also be launched to the space station several days before the end of the latest manned mission.

Due to module production delays, however, it was found expedient to put the next manned mission off until August.

But information from Kvant's telescopes and other Mir equipment will continue coming to earth.

The next crew to man Mir, who will stay there for six months, are in for a lot of work involved in receiving the new modules and putting them in operation.

The new modules will double Mir's weight.

State Commission Assesses 'Mir' Project

LD2104125689 Moscow TASS in English 1234 GMT 21 Apr 89

[Text] Moscow April 21 TASS—The crew of the fourth principal expedition on board the Mir orbital station, including Aleksandr Volkov, Serey Krikalev and Valeriy Polyakov, has fulfilled its program and is preparing to return to the earth. They are scheduled to land on April 27th. In the meantime, preliminary results of the huge work carried out on board the space laboratory since its orbiting in February 1986, are being summed up on the earth. This was the subject of a meeting held here by the State Commission of the Council of Ministers of the USSR. Today it passed a decision on the program of Mir's work up to the end of the year.

Invited to the meeting for the first time, apart from leading experts and scientists, were representatives of the central press. It is planned to make traditional their participation in the work of such important commissions—a surely splendid example of glasnost.

The heads of scientific and technical "sectors" of Soviet cosmonautics, who took the floor at the meeting, summed up the work done on the orbit by the three principal expeditions, which lasted 125, 326 and 366 days respectively. Four visiting crews, which included Syrian, Bulgarian, Afghan and French cosmonauts, have also contributed to the fulfilment of the set tasks. During this period 17 "Progress" vehicles had delivered to the

station more than 40 tons of instrumentation and equipment, materials needed by the life-support systems, and fuel. Members of these expeditions have ventured into open space on nine occasions and stayed there for a total of over 37 hours. Some 5,000 different filming sessions, scientific studies and experiments were carried out.

It was noted that many of the results obtained on the orbit were not only of scientific, but also of huge practical value. Several medical preparations and semi-conducting materials have already been put to practical uses. Members of the state commission paid much attention to the possibility of making practical use of other promising results, too. Brought to light also were certain problems requiring urgent solution.

The program of further using Mir was put to thorough discussion. Since two new spatial modules will be ready only in the second half of the year and time is needed to process the received data, it was decided to continue Mir's pilotless flight until August. The earth will continue to receive data during this period from telescopes of the "Kvant" astrophysical module and from other equipment. This will be followed up by a 6-month scientific mission of a new crew, which will receive and make operative the new modules. Their integration into the scientific complex will practically double the total mass of the station and its equipment. This will contribute to a more effective use of the orbital station's potential in the interests of science and national economy, ushering in the second phase of Mir's service life.

'Mir' Cosmonauts Describe Landing

LD2804171889 Moscow TASS in English 1652 GMT 28 Apr 89

[Text] Moscow April 28 TASS—"In the past few weeks of the flight we have completely prepared the Mir orbital complex for a three-month unmanned flight, by replacing all spent systems and assemblies," journalists were told at today's news conference in Star City by 40-year-old Aleksandr Volkov, the commander of the fourth expedition aboard Mir. Together with 30-year-old flight engineer Sergey Krikalev, and 47-year-old doctor Valeriy Polyakov he returned to earth in the descent module of the Soyuz TM-7 spacecraft at 6:59 Moscow time yesterday.

The cosmonauts were brought by helicopters to the airport and then to Star City. Barely 36 hours since the landing, the crew members moved freely, without any signs of strain and gave detailed answers to journalists' questions. All this despite the fact that Aleksandr Volkov and Sergey Krikalev spent five months in orbit and Valeriy Polyakov eight months.

Sergey Krikalev calmed down the journalists who were alarmed by yesterday's TV report that he received an injury during the landing. "We landed without problems in the pre-set area," he said. "The slight injury in the leg is nothing out of the ordinary. There were gusty winds in the area and therefore the landing was more rough than usual."

The Mir orbital station, manned by cosmonauts, has been in orbit since February 1986. It has six docking ports and one of them already received the Kvant astrophysical module in April 1987. The station hosted several crews in succession. It was planned that Aleksandr Viktorenko and Aleksandr Balandin would head for the Mir station several days before the completion of the current expedition but their mission was put off until August when the modules are expected to be completed. Information from the telescopes of Kvant and other equipment of the orbital complex will continue to come to earth in the automatic regime.

"We put our signatures on each new device we installed as a guarantee of their smooth performance," Valeriy Polyakov said smiling. Aleksandr Volkov added that all systems of the station were checked from the earth and their functioning was stable.

Supreme Soviet Confers Honors on Cosmonauts

LD2704144189 Moscow TASS in English 1422 GMT 27 Apr 89

[Text] Moscow April 27 TASS—The Presidium of the USSR Supreme Soviet has conferred to honours on the crew of the orbital space station Mir for courage and heroism displayed during their mission, it was officially announced here today.

Sergey Krikalev and Valeriy Polyakov received the titles of Hero of the Soviet Union and Pilot-Cosmonaut of the USSR.

Cosmonaut Aleksandr Volkov, who already holds the title of Hero of the Soviet Union, was awarded the Order of the October Revolution.

The Soviet spacemen Volkov, Krikalev and Polyakov returned to earth today after completing the first stage in the use of the orbital station Mir, the word meaning "peace" in Russian.

The station has been in orbit since February 1986.

Volkov and Krikalev spent five months on board the station, Polyakov, who was a member of the Soviet-Afghan crew, worked in orbit for nearly eight months.

Cosmonaut Polyakov Discusses Post-Flight Readaptation

LD2405135989 Moscow TASS in English 1343 GMT 24 May 89

[By TASS correspondent Vladimir Isachenkov]

[Text] Moscow May 24 TASS—Having returned to the earth on April 27th after an 8-month flight on the "Mir" station, Doctor Valeriy Polyakov got up at 6.30 A.M. the

very next day to watch the "120 Minutes" TV program and did his morning exercises without any safeguards—15-20 squats and spinal limbering up motions.

"On the third day after the landing Vladimir Shatalov, chief of the cosmonauts training center, was very much surprised to see me running", Polyakov said before flying for Crimea, where the cosmonauts and their families will spend the holidays this year. "A week before our return to the earth my shin muscles shrunk approximately 20 percent. The same happened with Aleksandr Volkov and Sergey Krikalev. True, this did not affect our physical abilities. For instance, I could run at 15 kilometers an hour on a treadmill for a minute 3-4 times a day. Our weight had not changed much as compared to what it was before take off".

Shrinking of shin muscles, lowering of calcium content in bones, changes in heart functions and water-salt exchange are unavoidable in conditions of weightlessness. All these changes are not dangerous for a cosmonaut's health when he is in orbit. However, the better a cosmonaut adapts himself to weightlessness, the more difficult it is for him to readapt to terrestrial conditions.

Soviet medics have worked out a set of prophylactic methods to combat the aftereffects of weightlessness in order to facilitate adaptation to terrestrial conditions. In the course of a flight cosmonauts must spend one hour a day on physical exercises, not included in the overall duration of their working day, which equals to 8.5 hours. They must run about five kilometers a day on a treadmill and "ride" more than ten kilometers on a bicycle ergometer. Additional exercises must be done with expanders and other appliances. Special "penguin" suits with sewn-in special rubber liners also help to bring more pressure to bear on the muscles. At the final stage of a long-term flight cosmonauts also undergo training on a special "Chibis" appliance which stimulates the flow of blood to their feet.

"As a physician, I had to set the example of conscientious attitude to the prophylactic system and did my best to improve and extend it", Valeriy Polyakov says. "For instance, the time of 'chibis' training was increased, exercises were intensified to strengthen the vestibular apparatus. By properly combining the available prophylactic means it is quite possible to carry out flights that beat Vladimir Titov's and Musa Manarov's record of 366 days."

Interview with Cosmonauts Volkov and Krikalev

18660124 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 18 Feb 89 pp 1, 4

[Interview by SOTSIALISTICHESKAYA INDUSTRIYA correspondent G. Lomanov with cosmonauts Aleksandr Volkov and Sergey Krikalev and physician Valeriy Polyakov: "We Can't Stand Still—We'll Be Overtaken"; article subhead reads "The Crew of the Orbital Complex Answers SOTSIALISTICHESKAYA INDUSTRIYA's Questions"]

[Text] ***They called from the Flight Control Center: "We have an idea. We'll give each journalist accredited with the Flight Control Center a communications session so that he can talk to the crew without interference. Any objection? Then we'll expect you Wednesday at 1300 hours."***

An unexpected proposal and quite apropos: February 20 marks the third anniversary of the launching of the "Mir" station. Aleksandr Volkov and Sergey Krikalev have been working in orbit for two and a half months; physician Valeriy Polyakov, almost half a year. Now the complex is coming into radio range...

SI: *"Donbass boys," thanks for agreeing to talk. I've taken questions mostly from readers' letters. Some, you may feel, are not for you, but for other specialists, but people are still interested in your opinions and judgments. I'm hoping for a frank conversation. These days it hardly pays to smooth over rough edges. Agreed?*

Volkov: We'll see. We'll answer those that we can. Those that we can't—don't hold it against us.

SI: *"Mir" has been in flight for three years. It's basically living quarters that had to be outfitted with scientific laboratory modules when it was already in orbit. So far only the "Kvant" has been docked. Four docks are still empty. There was some talk that the second module would be ready by spring of last year, then by fall, and now they've set the next date for the end of this year. Do you think that a nearly two-year delay is acceptable? And also, do you know the reasons?*

Volkov: Indeed, the module was supposed to have been docked last year. We were planning on it and getting ready. By the way, while we're speaking of the long-term program, we were supposed to dock two, not one. The fact that they are not ready is, of course, bad for us. The reasons for the disruption? Better to ask the specialists on Earth. Apparently not everything was worked out, like everywhere. The failure can probably be attributed to our less than perfect production technology and scheduling system. The fact that we are annoyed is clear. Nevertheless, the crew's work hasn't slacked off. We work with a full schedule every day. The studies scheduled on the modules are something else. In our opinion, they would have been more interesting both for science and for the national economy. Obviously, industry is trying, but it isn't succeeding.

SI: *We've talked for so many years about orbiting factories—isn't it time to move from talk to action? Do we have developed technologies for semi-commercial production in space? Can such production be set up on "Mir"?*

Krikalev: The question isn't exactly ours to answer. Technologies are developed on Earth, and the people there can probably give you better information on what already exists and what's being planned.

SI: *But why? After all, it's you and your comrades who are working the bugs out on them in orbit.*

Krikalev: Come on. We will be able to talk seriously about orbiting "factories" when a system of replaceable modules equipped with production facilities shows up. Semi-commercial production should begin as soon as they arrive.

Volkov: I'd like to add that we have a similar system right now, the "Ruchey." It's a device for separating a substance into the fractions required to manufacture drugs.

SI: *Much has been written about producing vaccines and highly pure chemicals in zero gravity. Is this area being developed, or has it died out? Are you, specifically, doing these experiments?*

Polyakov: The mission schedule for this expedition doesn't give the physician those jobs. Before my arrival, Titov and Manarov enthusiastically did experiments on producing highly pure reference substances. My opinion is that every opportunity needs to be taken to develop this area intensely. But....My comrades were right—only specialized, replaceable modules provide such opportunities. So it's a matter for the developers and industry.

Krikalev: Let me add that the shelf life of chemicals produced in biotechnology installations is limited. Therefore, these experiments are usually done just before landing, when the specimens can be returned to Earth. And that's why the work hasn't been scheduled for us.

Volkov: Remember, here in space we've had other semi-commercial "shops"—we grew crystals which were used in experimental radio engineering and electronics. Now, unfortunately, the service life of the units has run out, and new ones must be brought up by modules.

SI: *Your answers are literally "criticism from above." I hope that developers will take it into consideration. But let's go on. The list of questions is long, and the session is short. In the fall, we talked with your colleague Serebrov. He mentioned that the scientific research program for long-term orbital stations sometimes comes about spontaneously—someone makes a breakthrough, someone has something ready, and it goes aboard. What's your position? Is there a need for a coordination center, for broader and more open discussion of the programs and their success rate?*

Krikalev: The need for coordination is indisputable. The smoother the work, the better the results.

SI: *Are you interested in the outcome of the experiments you're doing? The newspapers have criticized the "Priroda" State Center because space photos are aging in its files. Do you know of similar cases, and have you tried to intervene?*

Volkov: We know of instances. We've talked about this often during our expedition. I became interested in the problem. "Priroda" State Center offers unique, valuable photos, but sectors of the national economy still don't know how to use them. There may not be enough advertising. If sector and enterprise heads learn about the capabilities of space photography, the center won't be able to fight off the buyers.

SI: *I can't agree with you. For many years, the specialists at the "Priroda" State Center have said with pride that they have hundreds of buyers. Whereas specialists from the national economy complain that they get copies that aren't suitable for computer processing. But they've decided against openly criticizing the center, they're afraid of arguing with a "monopoly"—because then they won't get anything.*

Krikalev: I think that both viewpoints are correct—yours and the commander's. I don't think it's a matter of someone deliberately holding back information. The fact is that the quality of copies is not high enough and that specialists don't know what to get or where to get it.

SI: *Is there a need for expeditions lasting about a year? Or is the "shift" method more effective, where a crew works 4-6 months and then turns the station and equipment over to the next crew? And another question—isn't a lot of time taken up by physical exercise, unloading the "Progresses," and other routines that, unfortunately, are unavoidable? One of your colleagues talking about the efficiency of scientific research said quite sharply, "Lower than a steam engine." What do you think?*

Polyakov: There aren't any absolute answers when you're determining how long work in orbit should last. Year-long expeditions are needed to test the possibility of a manned flight to Mars, about which there is a lot of talk now. Shorter flights are probably more advantageous for completing national economic tasks and scientific research, since they make it possible to quickly update programs and equipment and to send different kinds of specialists.

Volkov: About efficiency — physical exercise takes two hours a day; the rest of the time is for work. The fact that not all experiments are aimed directly at meeting practical national economic needs is something else. My colleague probably had that in mind when he talked about a "steam engine" efficiency of 3-5 percent. But look, we're performing the mission at a full 100%; in rare cases, when equipment malfunctions, at about 80 percent.

The Apollo program cost the USA $25 billion. But because technology specially created for it was used in other fields, the Americans got a threefold payback on their costs—the return is estimated to be $75 billion. Do you know of any examples of such use of "space" technologies here in our country?

Krikalev: We don't have very many new technologies specially developed for space. We've tried to use and adapt what we had. Obviously, the lack of resources and

the organizational difficulties are having their effect. As a result, the programs themselves are not efficient enough, and the results of the experiments leave much to be desired.

SI: *In the opinion of specialists, unmanned spacecraft still yield the lion's share of scientific information. I hope that you aren't offended by the question that arises in connection with that: Do we need manned flights at all?*

Krikalev: That question does trouble me. There is a problem. But to make good automatic equipment requires that the bugs be worked out in research techniques and equipment—and the best thing is to do it under actual conditions right in space. It's very difficult to develop a reliable automatic system, and it makes sense to refine it during manned expeditions.

SI: *Lunar bases, flights to Mars—doesn't it seem to you that there is an element of hair-brained scheming in these projects? Is there a need for them right now?*

Volkov: Hair-brained scheming? If we stop now, we'll live in the stone age. Moving ahead is necessary, and the time will come when we'll fly to other planets and settle them. But the first steps must be taken now, when else?

Polyakov: Our little library has a good selection of Tsiolkovskiy's books—he was also called a big hare-brained schemer. But sometimes you look through the portholes at the Earth, and you can't believe that you're flying in space. But we are, and that's reality. We can't stand still, or we'll be overtaken.

SI: *There's a lot I'd like to talk a bit more about, but you're moving out of range. What wishes do you have for the readers of our newspaper?*

Polyakov: Health and a healthy sense of humor.

Blagov on Plans for 'Mir' Modules, Mission Durations

18660125 Moscow IZVESTIYA in Russian
21 Feb 89 p 3

[Article by S. Leskov under the rubric "Details for 'Izvestiya'": "Line to the Space Home"]

[Text] **Three years ago, "Mir," which marked a new-generation of Soviet space stations, was launched. What has been done during since then? What are the near-term plans?**

Space time flies quickly! In three years, 15 Soviet and 4 foreign cosmonauts have stayed under "Mir's" roof. More than 200 scientific experiments have been conducted and almost 3,500 observations made (not counting the results of the current, fourth, main expedition). Spacecraft have docked with the space station 26 times—16 cargo "Progresses," 9 transport "Soyuzes," and the "Kvant" astrophysical module. The latter, by the way, is the justifiable pride of our own space program, since no one else has been able to develop such facilities.

Several years ago, one could have heard arguments like, which space program is better, Soviet or American? What's more important, a space station or a reusable spacecraft? The situation was complicated by the fact that the USA had shuttles and experience, although brief, working with the Skylab station. We could boast only of the "Salyuts"; the absence of a Soviet shuttle hindered objective comparison. Now the USSR has "Buran," but we see that USA has thrown major resources at the construction of the "Freedom" space station. So, the reorientation of our secret space competitor is proof that we took the right course by developing space stations.

What does the future hold for "Mir" and the space stations that will replace it? As Deputy Flight Director V. Blagov says, two new modules designated D and T are expected to dock with the spacecraft at the end of this year. Module D is intended to expand the station. Its compartments hold a more powerful onboard computer, a special "bicycle" for independent outings by the cosmonauts in open space, and other equipment. There is also a platform with scientific instruments and television equipment which turns in all directions, regardless of the position of the module itself. In the future, both the crew and a Flight Control Center specialist will be able to control them. In the opinion of scientists, such independent platforms represent the future of cosmonautics. The "Mir-2" station, which is still on the drawing board, calls for more than 10 geophysical and astrophysical platforms carried into space.

Module T is essentially a first attempt at a small pilot plant for producing various alloys and crystals in orbit. The module will have everything necessary for setting up space microproduction. Admittedly, the question arises, Will there be enough power on the orbiting station for the growing needs of science? After all, every joule is still counted on the "Mir." But new solar batteries should come with modules D and T, and the "Kvant" has unused fastening assemblies for additional panels.

The deadline for readying the modules has been pushed back more than once, but, as V. Blagov believes, the long construction time in this case was a blessing in disguise. In order to preserve the orbiting complex's symmetry, it is better if the modules are launched in pairs and docked with "Mir" within a brief time interval. These considerations will apparently be taken into account when the next modules—the optical and ecological modules, which are scheduled for 1990-1991—are launched. The latter is designed to confirm the ecological map of our country and the part of the planet visible from orbit. The world has no such map yet, but there is a great need for it.

Now, about near-term prospects for manned flights. The current expedition and the three that follow it will not be record-breakers—they will last 5-6 months each. No matter how much we would like to speed up the crossing of the one-year boundary set by Titov and Manarov, there is no point in hurrying. Primarily, we must carefully analyze the process of the rehabilitation of the crew back on the ground. And we cannot forget that, in the psychologists' opinion, the crew's efficiency gradually diminishes on a flight that lasts longer than 4 months; on a yearlong expedition, for example, the first two months and last two months are spent in a light, 50-percent work regimen. Stress, fatigue, and irritability have an effect not only on the crew itself, but also on the work of all the mission control staff.

So, the task of reaching the "Martian" frontier in 1.5 years can be given only to the eighth main expedition. I'm admittedly bothered here by the following circumstance. The matter of the extreme expense of a flight to Mars is still far from resolved, but orbital expeditions are already being planned in which we are deliberately proceeding to work with a crew whose efficiency is diminished. Has all this been weighed? Especially if one takes into account the existence in the orbiting complex of production modules which are extremely vital to our science and economy. Will they also, along with the crew, have to work at half strength?

A few words about the flight of the current crew, Volkov, Krikalev, and Polyakov. The "Donbass boys" are involved with the astrophysics research that is being done with the "Rentgen" and "Glazar" observatories, and they are continuing biotechnological, production, and medical experiments. It is regrettable that the science mission for this expedition includes no discoveries or bold approaches and that a great deal of the crew's effort goes to keeping all the orbital station's systems in order. It is hard to take consolation in the fact that the astrophysical studies are unique—after all, they are being done primarily in automatic mode. And, to be honest, we have somehow now become accustomed to every space flight being a breakthrough into the unknown, not a breathing space before future successes.

Cosmonaut Volk Discusses Development of Shuttle, Pilot Training

18660128 Moscow TRUD in Russian 4 Jan 89 p 4

[Article by V. Golovachev, who elicits commentary from Igor Petrovich Volk: "In Preparing for the Flight on 'Buran'"]

[Text] In a well-worn brown leather jacket over a flight suit, Igor Petrovich Volk has just crawled out of the cockpit of the jet airplane he was flying, an airplane he was testing, taking it into a spin, then climbing, then taking it into a spin again, then climbing again, making the airplane do exactly what is strictly forbidden in all the instructions...At times, it seemed to me that Volk was mentally still there, in the sky, taming the silver bird that was tumbling toward the ground...

He would look at me distrustfully, and his eyes showed a strange combination of fatigue and hardness, and maybe even annoyance...Volk was not saying what was clear in his face: why do we need this conversation at all, when it will hardly be published anywhere? And if it is published, then it won't do anything for him except cause the usual nuisances. But, having promised to meet with me, he couldn't not keep his word, and he answered my questions with forthrightness, without reservations, as he does all the time.

Volk, they told me, works "on the edge." I don't think that's quite true: he not only works on the edge, he lives there, too, in an impetuous fashion. His workday often lasts 14-15 hours. The airport, the plants, the design bureaus, the allied "firms," the temporary assignments...The tempo is stressful. And he's only 51 years old. This man seems to be testing his body, testing himself, for durability—how much overload can he endure, where are the limits? In something of a violent fervor, he has for many years assigned himself extreme regimens—in the same way that he tests airplanes—at the limits of potential, beyond the boundaries of the feasible.

Once, at 13 G's, the skin of his jet aircraft began to crimp. The metal failed, but he withstood it. Volk doesn't give in to "pressure" easily in life's collisions, either. "He has a difficult character, but it's truly character with a capital C," says one of the pilots.

And we spoke with Volk about Buran, about our reusable spacecraft. Igor Petrovich heads the group of cosmonauts preparing for the flight on Buran. The group was created as far back as 10 years ago, in 1978. At that time, besides I. Volk, the group consisted of the test pilots A. Levchenko, A. Shchukin, R. Stankyavichyus, and O. Kononenko. The fate of three of them ended dramatically. In 1978, while testing a new aircraft, O. Kononenko was killed during takeoff. A. Shchukin died not so long ago, testing an SU-26 aircraft. In the summer of last year, the group lost USSR pilot-cosmonaut A. Levchenko, because of illness—eight months after his space flight.

"Today," said Volk, "our group has seven people: test pilots R. Stankyavichyus, M. Tolboyev, U. Sultanov, V. Zabolotskiy, S. Tresvyatskiy, Yu. Sheffer, and me. What goes into the training program? Specific crews haven't been decided on yet—main and back-up crews, or, as they say now, first and second crews; everyone in the group is involved with testing aircraft. That is one of the important elements of training for the flight on the reusable craft. That's the only way to keep your form, sharpen your skills, not lose the special qualities that test pilots have..."

Professional test pilots are needed to test new space equipment. That is why experienced test pilots were chosen to train for flights on the Soviet reusable spacecraft. Three of them are no longer with us today. More than 10 years ago, O. Kononenko (extreme left) was killed when he was testing a new aircraft; A. Levchenko (second from left) died of an illness (brain tumor); and A. Shchukin (third from left) died in August of last year, when he went into a spin while piloting an SU-26 on a test flight. Continuing, from left to right, are the test pilots training for flight on Buran: I. Volk (group leader) and V. Zabolotskiy.

Test pilots training for Buran flight: (from left to right) R. Stankyavichyus, U. Sultanov, M. Tolboyev, S. Tresvyatskiy, Yu. Sheffer.

"The tests provide a variety of incidents that would be impossible to foresee in training sessions. Passing through the crucible of the most complex situations, the pilot gains unique experience and the ability to instantly foresee an event and take unusual measures, acting against psychophysiological reflex.

"A pilot who has gotten into a tough situation usually just thinks about how he can get out of it as quickly as possible. And that's natural. But we test pilots have another concern: how to take a situation to the limit. But there's no bravado here, no careless risk-taking—that would simply be stupid. Exact calculation, knowledge of the equipment, fast analysis of a rapidly changing situation, and the art of prediction—that's what makes it possible to go into a spin, into untried territory, and find a way out of it. So the experience of a test pilot is very necessary for flying on Buran.

"Of course, the people in our group are studying the theory and the design of the reusable craft and are training on special simulators—in a word, doing everything that's usually done. But we are devoting special attention to test-pilot work."

[Golovachev]: But doesn't that represent an additional risk—do those who are training for the flight on the reusable craft need it?

"There is a risk," Volk said, "in an ordinary parachute jump...But it's the test pilot's profession to test aircraft. It's his whole life. What is a test pilot if he doesn't test aircraft: Of course, when the specific crews are named, they will have to stop testing aircraft for a while. But until then..."

And Volk made a decisive gesture with his hand. But I recalled one of Volk's test flights in which a new aircraft, after tearing away from its brakes, rushed along the runway, took off, but the landing gear lost its rubber. Ground control ordered him to eject. The airplane couldn't land on the brake drums. But Volk, stubborn as always, took it upon himself to land the aircraft...And how many such incidents there were!

USSR pilot-cosmonauts Yu. Gagarin, A. Nikolayev, P. Popovich, and V. Bykovskiy near one of the models of the reusable craft. The photo was made more than 20 years ago. A TRUD reader sent the photo to the newspaper. The person who took the photo (of the film frame) was not named in the letter.

But let's get back to Buran. Unfortunately, it wasn't reported when the work on the development of the reusable spacecraft actually began. I asked Volk to tell me about it.

"In the first half of the 60s," he said, "our country was developing a vehicle that could be considered a landmark along the way to the reusable craft. One such experimental airplane, for example, was placed on a large aircraft and taken up to an altitude of 8-10 kilometers, and, released from there, the airplane made a flight and landed. I even took that model up; that is, I accelerated along the runway, took off, and landed after a few seconds...

"There were a number of unanswered questions. One of them had to do with the thermal shielding. Say the nose of the fuselage has to withstand temperatures of about 1500 degrees. After a lot of ground-based studies and experiments, checks were made in actual conditions. The first model (whose lines were far from those of today's Buran) was sent up 4 July 1982. Then other manuevering satellites were put into space orbit—in March and December of 1983 and in December 1984...In doing this, we found the best designs. The cigar-shaped hull of the model was completed with small triangular wings. And the hull bore the insignia 'SSSR.'

"Those were the first models of the Soviet aerospace craft that, in addition to everything else, provided extremely valuable data on the operation of the heat-shielding tiles..."

[Golovachev]: Before Buran went into space, its prototype made a number of flights in the atmosphere. Who piloted that vehicle? How did the flights go?

"It's known that Buran, like the American Space Shuttles, does not have aircraft engines for flight in the atmosphere," Volk said. "It returns to Earth and makes a landing like a glider. Buran's rocket engines are used only in space, beyond the atmosphere. Because of that, to test the craft in the atmosphere, it had to be fitted with four jet engines that make it possible to take off from and land like an ordinary airplane.

"The first pilots assigned to take the prototype up were me and Rimas Stankyavichyus. That was, understand, not before, but right after the November holidays. They made a special effort, I think, to change the tests to a day after the holidays, so there wouldn't be any thought of 'attaching' the flight to a celebratory date. So, on 10 November 1985, Rimas and I took our places on the flight deck of the Buran prototype..."

[Golovachev]: You were probably worried, weren't you, about how it would behave—because the machine hadn't been up even once?

"That kind of worry gets in the way. I already said, testing new equipment in flight is my job. I think we're very lucky. The first climb of an experimental airplane—every test pilot dreams about that, but not every one is so lucky over the course of his flight career.

"After getting permission, we left the runway, climbed to a low altitude—about a thousand meters—made a circle, and then came back for a landing. The entire flight lasted 12 minutes. Everyone greeted us very warmly. There were even girls with flowers...You don't generally get that kind of greeting."

[Golovachev]: And the second flight?

"It also took place after a holiday. It was on 3 January 1986. It lasted 36 minutes this time. The third flight was on 27 May...There were 24 flights, in all. The last one, the 24th flight, was fairly recently—15 April of last year, seven and a half months before the launch of the actual Buran. During that time, Tolya Levchenko, Sasha Shchukin, Ivan Bachurin, and Aleksey Boroday flew on the Buran prototype.

"Those flights mainly tested the interaction between the systems of the reusable craft and the airfield radio and radar equipment, which was important for perfecting the automated landing system."

[Golovachev]: Were there other tests, besides the flights on the Buran prototype?

"Of course," Volk said, "and very extensive ones. For example, a special test rig was fitted with Buran's equipment. Different conditions of actual flight were simulated here. More than 1,400 such "flights" were made.

"The crews trained on another rig (dynamic pilot rig). Some 3,200 hours were spent, in all, on that rig. The pilots not only mastered the art of controlling Buran, they also tested the control organs of the reusable craft and evaluated them.

"I'd especially like to say something about the extensive program of test flights aboard flying laboratories. This is where the complex automated landing systems got their OK's, where the possibilities of maneuvering on the approach to the landing strip were studied, where the interaction of the ground complex and the onboard equipment was perfected. The TU-154 and MIG-25 airplanes were chosen for that work. Of course, the flight characteristics of the TU-154, for example, are quite different from those of Buran. The reusable craft dives rather steeply toward Earth and levels off when it's not far from the landing strip. The TU-154 can't fly like that. So we had to completely 'corrupt' its aerodynamic characteristics.

"In the course of testing, the flying laboratories went up nearly a thousand times. Landings were made in automated mode often. The flying laboratories have two control systems—their own aviation system and Buran's system. When unforeseen difficulties arose during the testing of the automatic equipment of the reusable craft, we switched to the regular control system.

"Tests were done at the flight-testing institute and at the Baykonur cosmodrome—on the very same runway that Buran landed on."

I. Volk, as usual, spelled out the gist of things with a few words. But any aviator would admit that a thousand test flights is quite a lot. Each flight was preceded by painstaking preparation and followed by comprehensive analysis. That stressful work required that the test pilots give it their all. A great deal depended on their mastery, experience, intuition, and ability to analyze the operation of the most complex systems during actual flight. The success of the Buran mission is, to a great extent, the success of our aviation industry and the test pilots.

I. Volk is not just a first-class test pilot and USSR pilot-cosmonaut (he flew in space for 12 days in 1984); he is also a highly qualified, degreed engineer and specialist who knows the fine points of the design of the reusable spacecraft, to the last little bolt. And it was very important to hear his opinion of what the next Buran flight should be—manned or unmanned.

"I would hope that the first success doesn't lead to euphoria, to less rigorous requirements in the evaluation of the various systems, assemblies, etc.," Volk said. "Space, as we all know, doesn't forgive mistakes. A manned Buran flight, in my opinion, will require a great deal more work. It may make sense to check out the complex flight program in automatic mode first. All the systems that will be used in manned flight need to be tested."

[Golovachev]: In some of the letters that come to the editor, readers ask whether such an expensive craft like Buran is needed.

"You can't halt progress. A reusable spacecraft is absolutely necessary. It's something else if they want to have a more efficient program of its use..."

Project 'Radioastron'

18660121 Moscow ZEMLYA I VSELENNAYA in Russian No 1, Jan-Feb 89 pp 13-17

[Article by V. V. Andreyanov, candidate of technical sciences, USSR Academy of Sciences Space Research Institute, under the rubric "Space Program": 'Radioastron' Details the Universe"; first paragraph is source introduction]

[Text] **The prospects of basic research in astrophysics are linked to the improvement of two telescope parameters—angular resolution and sensitivity. One technique that makes it possible to increase angular resolution by many orders of magnitude is radio interferometry. The use of this technique with the transport of one of the elements of the radio interferometer into space is planned in the international project Radioastron.**

From ground-based telescopes to space-based telescopes

The problems associated with the origins and evolution of Earth, the Solar System, our galaxy, and the Universe have given rise to a multitude of theories and hypotheses. But every time that developments in technology result in new instruments and observation techniques, cosmogonic and cosmologic theories and hypotheses undergo substantial change and development. We all know that theoreticians literally "attack" each new observation fact. That is what happened when, for example, the IRAS satellite (United States, Holland) yielded the very rich and astonishing information about the infrared picture of the sky. It is also what happened in 1987, when astrophysicists observed the burst of the supernova 1987 A and its hard x-ray emissions (ZEMLYA I VSELENNAYA, 1988, No 3, p 116—*Ed.*). It happened again when ground-based networks of very long baseline radio interferometry (VLBRI) that made it possible to obtain pictures of greater detail of radio sources in space became operational (ZEMLYA I VSELENNAYA, 1983, No 1, p 4—*Ed.*). In recent years, scientists in the USSR, the United States, Western Europe, and Japan have been working on projects involving **ground-and-space-based radio interferometers,** in which at least one telescope is carried into space.

The development of such instruments will make it possible to solve problems that are either very difficult or altogether impossible to solve with ground-based radiotelescopes. After all, ground conditions create certain difficulties for observation. Among those conditions are limited angular resolution, which is determined (for a given radio wavelength) by the Earth's diameter, and the existing limits in radiotelescope antenna size that are due to the effects of such factors as gravity and winds. Moreover, the Earth's atmosphere is not transparent for waves longer than 10 meters or shorter than 1 centimeter (except for a few transparency "windows"). But those are not the only limitations. Ground-based observations are limited by the geographic arrangement of telescopes (the baseline of such radiotelescopes is stretched along a meridian, which means that radio sources along a north-south line are studied in more detail) and weather conditions.

All these obstacles can be overcome if we place one or several space-based radiotelescopes into orbit. Space-based radio interferometers will become instruments that hold promise for future astrophysical research and will make it possible to produce new findings in astrometry, geodynamics, and geodesy.

Work on the Radioastron project has been under way in this country since the early 1980s, at the USSR Academy of Sciences Space Research Institute, under the scientific direction of USSR Academy of Sciences Corresponding Member N. S. Kardashev. USSR Academy of Sciences Corresponding Member V. M. Kovtunenko, professors Sh. A. Vakhidov and A. S. Selivanov, and their colleagues are making a tremendous contribution to the preparatory effort. Participating foreign specialists includes those from countries such as Australia, Hungary, Holland, Canada, Finland, and FRG.

The path to unraveling the mysteries of the unknown

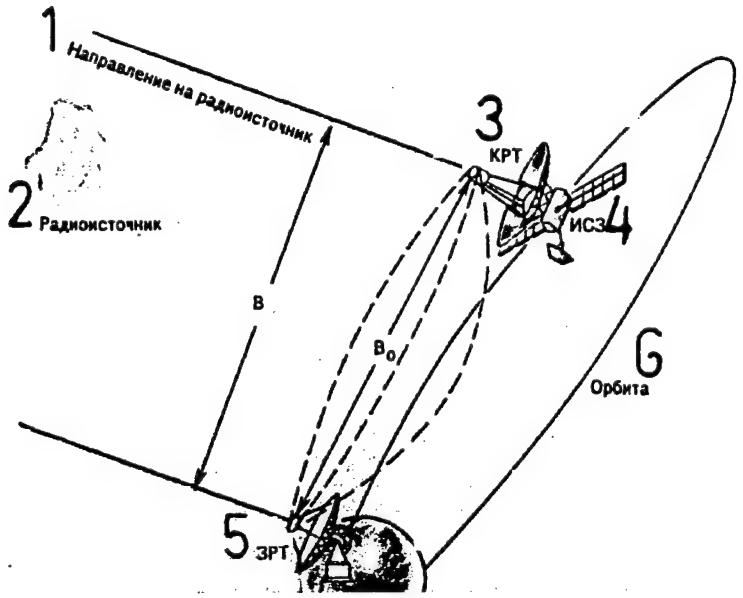
In the last 10-20 years, galactic and extragalactic astronomy has traded on such concepts as pulsars, quasars, black holes, speeds greater than the speed of light in celestial phenomena, gravitational lenses, and supergiant emissive power of certain sources.

Many characteristic features of these targets are recorded by scientific instruments rather reliably, but the inadequate resolving power and sensitivity of instruments and the sparseness of observation data prevent the targets from being puzzled out completely.

The angular resolution (the smallest discernible angle) of a space-based interferometer is defined as the λ/B ratio, where λ is the wavelength picked up from the radio emission source and B is the length of the projection of the baseline B_0 onto the "picture" plane that is perpendicular to the direction to the source. That is, based on its resolution, such an interferometer is equivalent to a solid antenna with a gigantic diameter, as depicted by the dotted lines on the figure. That would make it possible to have a superresolution, which is extremely important, since it has been established that many of the phenomena mentioned above are, to a great extent, detected specifically as compact details of space formations.

Astrophysical tasks

They consist, first, of a study of the nature of radio sources in space and related phenomena that is based on the images of compact details of the central regions of active galaxies and quasars. This is necessary for research involving the processes that take place when there are incredibly large releases of energy in the cores



Configuration of ground-and-space-based radio interferometer

Key: 1. Direction to radio source—2. Radio source—3. Space-based radiotelescope—4. Artificial earth satellite—5. Ground-based radiotelescope—6. Orbit

of these targets. Tracking the behavior of radio sources in time is aimed at studying their evolution, detecting shifts of compact formations that occur at speeds greater than the speed of light, and explaining the causes of the transport of matter in narrow streams. It should be noted that these processes cannot be studied in the laboratory.

Second, the fact that, even for Radioastron, pulsars remain point sources enables their use not only for calibration purposes, but also for studying the region of scattering of radio emissions in interstellar plasma.

Third, targets of study will also be maser-type sources that have hydroxyl and water vapor emission lines. In a number of instances, the structure and dynamics of these sources are linked to processes of star formation. Masers are extremely powerful radio sources and are convenient for perfecting a space-based interferometer.

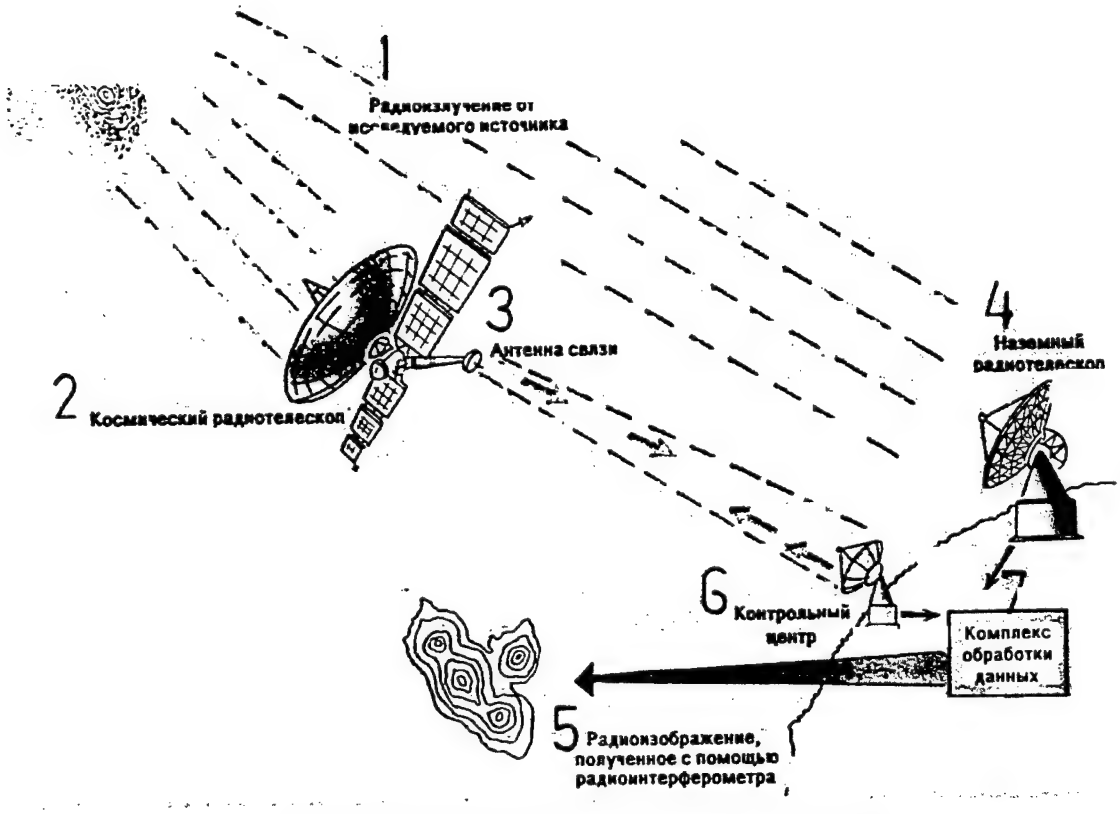
And fourth, the large Radioastron baseline will make it possible to be more precise about certain space distances, which is important for cosmology and astrometry. Because of the incredible distance from the ground-based observer, the spherical front of radiowaves coming from the sources is perceived by us as flat. In order to "read" the curvature of the front (and thus determine the distance to the source), receiving stations must be spread very far apart, which is effected by the considerable distance between the space-based radiotelescope and Earth.

Features of the space-based radio interferometer

Unfortunately, improving the angular resolution of a radio interferometer also requires increasing its sensitivity, since increasingly weaker emissions coming from increasingly smaller elements of the radio source must be distinguished. That is why, when resolution is increased, the physical dimensions of the radiotelescope antenna area must also be enlarged, as must the passbands of the frequency receivers and the coherent signal storage time; the noise temperature of the receivers must be lowered.

In order to construct a detailed radio image of the source, it is not enough to merely increase the length of the baseline—that helps only to distinguish the finer details on the image. In the process of observing the radio source, both the length of the baseline B_0 and its attitude in the "picture" plane must be changed successfully. With ground-based VLBRI, this is achieved as a result of the Earth's rotation; whereas with ground-and-space-based VLBRI, it is achieved primarily because of the motion of the space-based radiotelescope.

Unlike ground-based VLB radio interferometers, space-based radiotelescopes shift not only in relation to the radio source, but also in relation to each other, at high, unsteady speeds of as much as 10 km/s. Moreover, data from the space-based radiotelescope are "delivered" to Earth for correlation with the data of ground-based radiotelescopes through an extended satellite-to-Earth



Operation of ground-and-space-based radio interferometer

Key: 1. Radio emissions from source—2. Space-based radiotelescope—3. Communications antenna—4. Ground-based radiotelescope—5. Radio image produced with radio interferometer—6. Control center—7. Data processing complex

radio link that is vulnerable to interference. All this also distinguishes the output signals of the space-based radiotelescope from those of ground-based radiotelescopes: the difference consists in a time delay, in Doppler frequency shift, and in signal-to-noise ratio. That is why the interference equipment must be "capable" of handling a considerably larger discrepancy in signal differences than must the VLBRI equipment.

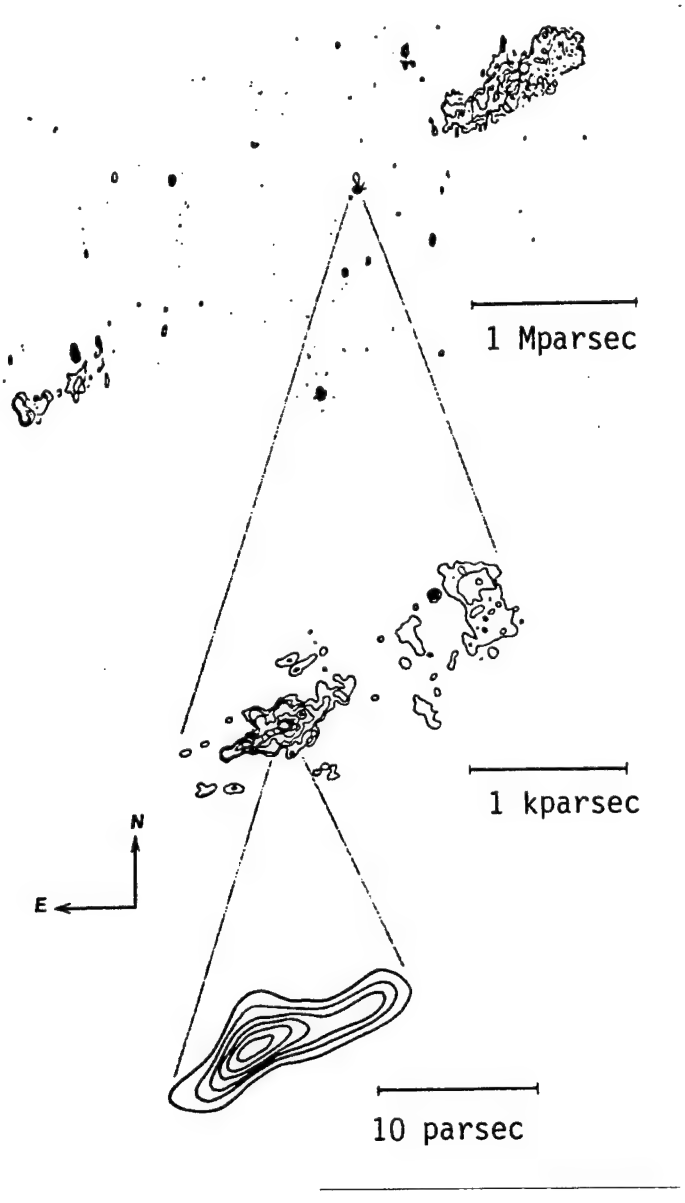
Many domestic and foreign space-based radiotelescopes will form the interferometer network jointly with the space-based radiotelescope. For that reason, one of the most important tasks consists of coordinating international efforts in terms of compatibility of technical parameters, data recording format, and observation schedule. For that, on one hand, it is desirable to use existing VLBRI equipment and techniques. But that, unfortunately, cannot be done completely. On the other hand, the improvements that are being made in the VLBRI equipment must be universal for operation with the space-based interferometry network elements being designed in various countries. This especially pertains to equipment for processing the data coming from the space-based radiotelescopes and the ground-based radiotelescopes.

Basic parameters of the Radioastron interferometer

"Radioastron" consists of four large interrelated systems: a space-based radiotelescope, ground-based radiotelescopes, a radio communications system, and a data processing system.

The **space-based radiotelescope** will be placed on a specially designed artificial earth satellite (weighing nearly 5 tons) with three-axis attitude control. In the first stage of research, it will have a small antenna (10 meters) in the form of rigid shields made of composite materials; radioastronomy double-polarity receivers in four ranges (327, 1665, and 4830 MHz and 22.3 GHz); and signal conversion units.

Several ground-based radiotelescopes, among which at least one (near Yevpatoriya) will be located next to the station for receiving data from the space-based radiotelescope on a wideband communications channel from the satellite. Functionally speaking, the ground-based radiotelescopes are similar to the space-based radiotelescope, but their output binary signals will be fed directly for processing or recording.



Contour map of radio galaxy 3C 236, with increasing resolution [10 parsecs, 1 kparsec, 1 Mparsec] (Astronomy and Astrophysics, 1985, 148)

The **coherent, two-way Earth-to-satellite-to-Earth radio communications system** will make it possible to transmit information from the space-based radiotelescope at a rate of up to 144 Mbit/s.

And finally, there is the **system for preliminary processing of data,** which effects master interferometric processing of the data from the space-based radiotelescope and the ground-based radiotelescope next to the receiving station.

The first stage of the project (in the first half of the 1990s) calls for placing a space-based radiotelescope into an orbit with an apogee of about 70,000 km, which exceeds the maximum distance between radiotelescopes in ground-based systems by a factor of almost 10—this represents an achievable angular resolution of up to 3 x 10^{-5}seconds of arc. The satellite has a revolution period of about 24 hours and an orbital inclination of 60-65°.

The space-based radio interferometer's flux sensitivity will be 30-300 Mjy (1 jy = 10^{-26} W/m^2/Hz). It will be achieved by expanding to 32 MHz the frequency band of the noise-like radio emissions received from sources,

cooling the receivers of the space-based and ground-based radiotelescopes in order to lower their noise temperature, and effecting coherent signal storage intervals of up to 100-1000 s. Such sensitivity is hoped to be able to puzzle out several dozens of radio sources that ground-based VLB radiotelescopes are unable to represent in detail.

The **Radioastron project is a long-term program for studying deep space.** Its final stage calls for the creation of a space-based aperture synthesis system consisting of several space-based radiotelescopes at various distances from the Earth, with periods of revolution ranging from 24 hours to a year, and operating in the millimeter range of radiowaves. Such a system will make it possible to begin constructing spatial structures and structures of greater detail of several galactic and extragalactic objects.

Meeting of Intercosmos Space Physics Group

18660123 Moscow ZEMLYA I VSELENNAYA in Russian No 1, Jan-Feb 89 pp 46-48

[Article by N. A. Frolova, Intercosmos Council of the USSR Academy of Sciences, under the rubric "Symposia, Conferences, and Congresses": "Meeting of Space Physicists"]

[Text] The 22nd meeting of scientists and specialists of Socialist countries of the permanent working group "Space Physics" in the Interkosmos program was held in April 1988, in Tbilisi. The plenary session took place on April 12—the World Day of Aviation and Cosmonautics. After the official opening, the deputy director of the USSR Academy of Sciences Space Research Institute and chairman of the Space Physics group, Prof. V. M. Balebanov, spoke about the principal findings of joint work in the field of space physics in 1987. Reports were then heard from GSSR Academy of Sciences Corresponding Member D. G. Lominadze, on plasma mechanisms of pulsar emissions, and USSR Academy of Sciences Corresponding Member R. A. Syunyayev, on the observations of hard x-ray emissions of supernova 1987A from aboard the Kvant astrophysics module.

Subsequent work was done in various sections. We will list them: "Space Plasma," "Astrophysical Research," Study of Objects in the Solar System," "Use of Space Vehicles for Geodesy and Geophysics," "Space Instrumentation," "Information Provision of Space Experiments," and "Space Materials Science."

Taking part in the meeting were many well-known Soviet scientists and major foreign specialists—from Bulgaria, Hungary, GDR, Cuba, Mongolia, Poland, Rumania, and Czechoslovakia.

Some Findings

The meeting's participants discussed top-priority goals as well as promising research directions. As everyone knows, in July 1987, the second Soviet-Bulgarian flight took place, on the Mir orbital station. During the flight, the joint crew performed a complex of experiments in the Shipka program, some of which were preliminarily examined at the meeting (ZEMLYA I VSELENNAYA, 1988, No 5, second page of cover—*Ed.*). Among the experiments were those on the Terma and Parallaks-Zagorka instruments, experiments designed for studying the atmosphere, auroras, spatial structures of the glow of emission layers, and the station's own glow. And while those instruments were modifications of instruments created earlier in the Intercosmos program, the highly accurate photometric camera Rozhen was an entirely new instrument that, in addition to that flight, will be used in many future astrophysical studies.

Intercosmos space physicists also prepared a great many instruments and experiments for the Phobos project, which began with the launch of two Soviet spacecraft in July 1988 (ZEMLYA I VSELENNAYA, 1988, No 5, p 3—*Ed.*).

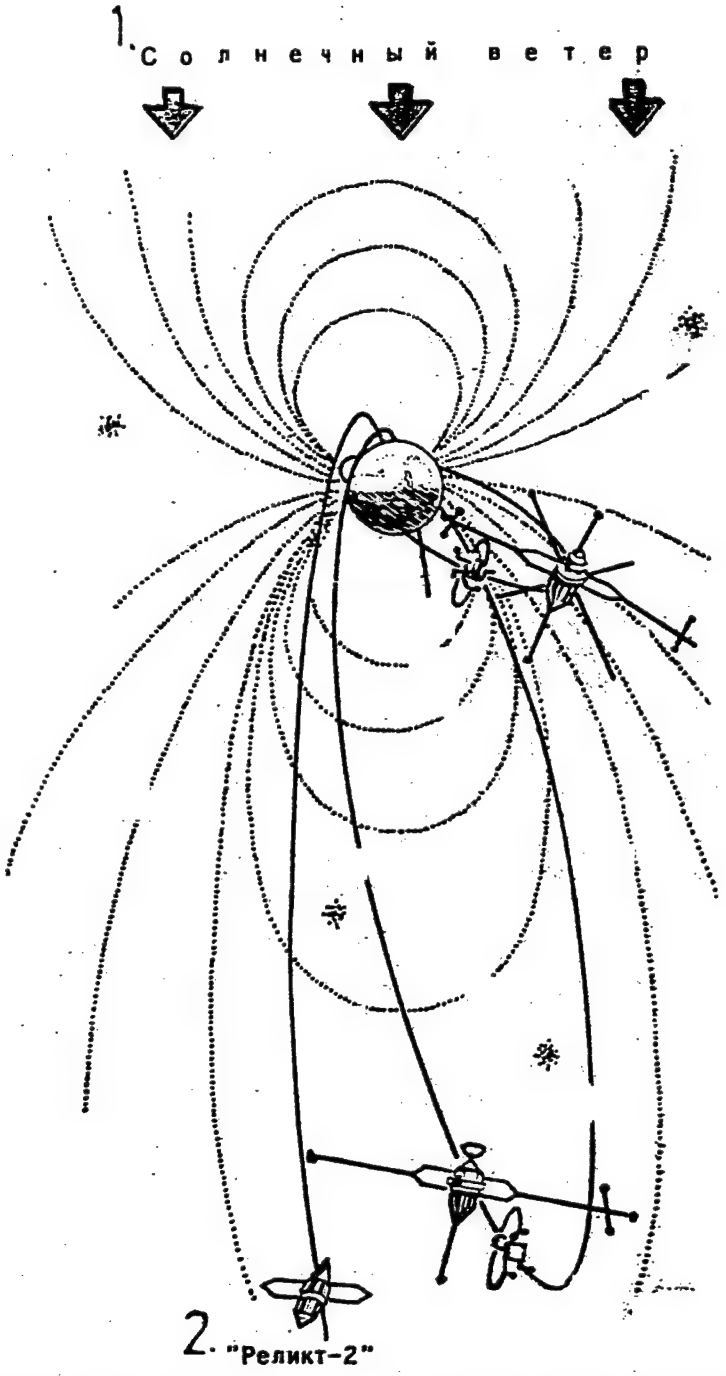
High marks were given at the meeting for the successful work of the Czech specialists who created an automated stabilized platform for pointing the television camera at the cometary core in the Venus-Halley's Comet project (ZEMLYA I VSELENNAYA, 1986, No 5, p 5—*Ed.*). Now Soviet and Czech specialists are reworking the platform to install it on the Mir orbital station.

Promising Collaboration

Planetary Studies.

The attention of the meeting's participants was focused primarily on examining a plan for collaboration in space physics for the period 1991-1995 and up to the year 2000. The Soviet Union invited socialist countries to participate in major projects involving further study and peaceful development of space.

This pertains first of all to the Mars-94 project, which is a component part of the program proposed by Soviet scientists, Mars-2000, which involves using unmanned spacecraft to bring Martian soil samples back to Earth. The country-participants of Intercosmos and other, capitalist countries have expressed the wish to participate in the formulation of this complex scientific program, in the selection of the most interesting experiemnts, and in the creation of the equipment. Specialists from socialist countries, for example, want to take part in the development of the television camera, the ion and neutral gas mass spectrometers, the magnetometers, the electron spectrometers, the Fourier spectrometer, the complexes for plasma and plasma-wave measurement, and the subsatellite for studying the gravity field of Mars.



Trajectories of auroral and tail probes in the Interbol project and the orbit of the Relikt-2 spacecraft, on which plasma and magnetic measurements will be performed in synchrony with the Interbol project.

Key: 1. Solar wind—2. Relikt-2 spacecraft

The "planetary" section also discussed other projects of the near future—those for studying Venus and small bodies of the solar system—and projects slated for the more distant future—those involving study of the giant planets of Jupiter and Saturn and the asteroid Titan.

High-Energy Astrophysics

At present, a project involving a large, unique orbital observatory Spektr-Rentgen-Gamma is being prepared for solving problems associated with cosmology, extragalactic

astronomy, and stellar astronomy. It will represent a major step in producing extremely valuable information on the Universe—information on neutron stars, black holes, pulsars, and sources of cosmic gamma-bursts.

This project will be carried out on the basis of a broad international cooperative effort, and significant developments will be effected by socialist countries. This pertains, for example, to the creation in Czechoslovakia of a mechanical design for the principal instrument of the project—the X-SPECT telescope (designed for high-resolution spectroscopy and the plotting of images of weak x-ray sources)—and the steerable platform for pointing the telescope at the x-ray sources; the creation and manufacture in Hungary of a multiprocessor onboard computer and, in Bulgaria, a star seeker for determining the coordinates of the steerable platform and the optical observations of the x-ray sources; and, in GDR, a mirror telescope.

Bulgarian and Hungarian scientists will also take an active part in another highly complicated project slated for a future five-year plan,—Radioastron—cm, the first part of the immense Radioastron program—involving a ground- and space-based radiointerferometer of the centimeter range for a high-angular-resolution study of the structure of powerful compact sources of radio emissions (the nuclei of active galaxies; quasars; pulsars; black hole vicinities; and the center of our galaxy).

At the meeting, the Intercosmos space physicists also defined what their contribution will be in another extremely important project, slated for the beginning of the 1990s—Relikt-2. It will continue research that was begun aboard the unmanned Prognoz-9 station in 1983-1984 on the large-scale anisotropy of relict radiation (ZEMLYA I VSELENNAYA, 1984, No 4, p 5—*Ed.*). This will make it possible to obtain new information on the distant past of the Universe. Bulgarian specialists are tackling the manufacture of the radiometers and the star seeker, while the Polish and Czech specialists are taking care of the development of the wave and plasma complexes.

It must be emphasized that the radiometers being created for this unique space project can be used in the study of natural resources, in radio measurement technology and communications; that is, they will find application in practical affairs herre on Earth.

Solar-Terrestrial Physics

Space physicists have a lasting interest in the study of the sun, its activity, and the Earth's atmosphere. Over the past 20 years of the existence of the Intercosmos program, a "solar" series of satellites have been launched: Intercosmos-1, -4, -7, -11, and -16 (ZEMLYA I VSELENNAYA, 1976, No 6, p 88—*Ed.*). Now specialists from Bulgaria, GDR, Poland, Czechoslovakia, and the USSR are designing instruments for experiments that study x-ray active formations in the solar atmosphere and processes that take place in solar plasma—the Koronas-I, F project and the Neytron project. These new projects involving complex research of the sun will have, in addition to scientific value, a practical value: analogous instrument packages can be used for predicting solar activity, for solving problems associated with hydrometeorology, and for evaluating radiation fields in near-Earth space.

The study of cosmic plasma—the basic state of matter on the sun, in the interplanetary medium, and in near-planet space—is called for in the Interbol project. The project will launch several space vehicles that space physicists will use to conduct research on the Earth's magnetosphere and the three-dimensional fine structure of plasma formations in the tail of the magnetosphere, as well as to study the magnetospheres of other planets. New data will help our understanding of the solar-terrestrial relationships.

Space-based materials science is acquiring a great deal of significance for the national economy. This field of research emerged in the framework of the Space Physics group almost 10 years after other areas of research, but it has already reached the stage of development of special production equipment. At present, the Czech furnace Kristallizator-ChSK-1 is in operation aboard the Mir orbital station. The launch os another unit is expected. All 10 Intercosmos country-participants are taking part in the preparatio of experiments involving space-based materials science.

The meeting's participants noted the excellent organization of the regular meeting of space physicists of socialist countries and the great amount of service in that regard provided by the staff of the city Laboratory of the Abastumani Astrophysical Observatory of the GSSR Academy of Sciences.

All will long remember marvelous Tbilisi, the hospitable land of Georgia, its hard-working, talented people, the unmatched natural surroundings, and the remarkable cultural monuments.

UDC 629

Problem of Convergence with Several Asteroids

18660140a Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 29 Jul 88) pp 3-8

[Article by V. A. Zhirnov and M. L. Lidov]

[Abstract] New results for the problem involving convergence of a spacecraft with several asteroids represent a continuation of work reported by the authors in 1988 (KOSMICH. ISSLED., 1988, Vol 26, No 4). With Hestia

(No. 46) chosen as the first asteroid approached, hypothetical approaches with N asteroids are plotted, with N = 2, 3, 4, 5. Variations are described in which loss of characteristic velocity due to the approach does not exceed 0.069 km/sec (for 2 asteroids), 0.255 (for 3), 0.611 (for 4), or 1.36 (for 5). A linear optimal correction algorithm is used to perform the numerical iteration procedure described in the earlier work for solving the nonlinear problem of convergence. The numerical experiments confirm the effectiveness of using an iteration procedure and a linear problem of generalized linear impulse trajectory correction to determine a quasioptimal solution of a problem involving convergence with a given number of asteroids. Figures 1, references 3 (Russian).

UDC 531.391

Evolution of Revolutions of Satellite With a Hinged Viscoelastic Rod in a Circular Orbit
18660140b Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 8 Apr 88) pp 15-24

[Article by Yu. G. Markov and I. S. Minyayev]

[Abstract] Motion around the center of mass of a mechanical system (a satellite) consisting of a solid symmetrical body and a removable viscoelastic rod positioned along its axis of symmetry and attached to the body with a viscoelastic hinge is examined. The center of mass of the satellite moves in a circular orbit, and the bending oscillations of the rod do not affect its motion. Approximation equations that describe the evolution of the system's motion are derived by dividing the motion into stages and constructing a phase portrait of the averaged system. Figures 3, references 4 (Russian).

UDC 629.7

Investigation of Optimal Two-Parameter Control of a Spacecraft Moving in the Atmosphere
18660140c Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 14 Apr 87) pp 64-70

[Article by N. L. Sokolov]

[Abstract] Because of the considerable amount of machine time required by numerical solution of problems involving optimal control of a spacecraft, the author asserts that approximate analytical solutions are more suitable for the task. He performs a study of the optimal control of a spacecraft in an atmosphere, the motion of which he describes with a system of differential equations. The approach taken here enables study of optimal control without the need for assumptions that the slope angle of the velocity of motion relative to the local horizon is either constant or negligible or that the lateral range of flight is negligible. The structure of two-parameter control (angle of attack and angle of roll) is determined for problems with various optimized functionals and boundary conditions. Figures 2, references 15: 12 Russian, 3 Western.

UDC 550:388

Dynamics of Charged Resonance Particles in a Field of Cyclotron Electromagnetic Waves
18660140d Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 20 Jul 87) pp 71-75

[Article by N. M. Shyumme and N. I. Izhovkina]

[Abstract] Results are presented for calculations involving the dynamics of the interaction of fluxes of charged particles and cyclotron electromagnetic emissions. Spikes in the tail of the distribution function that were observed in earlier experiments for the low-latitude upper ionosphere are assumed to be associated with multiple passes through the region of resonance interaction and the region of particles trapped by the magnetosphere and cyclotron waves propagating along the magnetic lines of force. The authors propose a physical model of the formation of particle fluxes with uneven spikes by the high-energy tail of the inner magnetosphere. The interaction of protons and ionic cyclotron electromagnetic waves is examined, as is the interaction of electrons and "whistler" electron cyclotron waves. In the experiments that were conducted, quasimonochromatic whistlers were observed to be emitted from electron fluxes at a frequency of ω approximately $\Omega_e/2$. The division of resonance and nonresonance particles in the interaction with such wave packets can apparently be amplified in regions of the magnetosphere in which the formation of waveguide channels is most probable. Resonance velocity can be reduced substantially when the waves and particles pass near the skin layer for the waves and can approach the thermal velocity of the particles. The authors conclude that, in regions with elevated electromagnetic field gradients and/or in waveguide channels, the time-and-space division of the particles can amplify diffusion of resonance particles in terms of pitch angle and can create spikes in the tail of the distribution function. Figures 1, references 9: 4 Russian, 5 Western.

UDC 551.510.535.2

Irregular Plasma Fluxes at the Polar Caps With a Northward IMF Component
18660140e Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 29 Dec 86) pp 76-83

[Article by E. M. Dubinin, P. L. Izraylevich, and N. S. Nikolayeva]

[Abstract] Based on data collected by the Interkosmos-Bolgariya-1300 satellite, the convection picture over the northern and southern polar caps with a northward IMF

component and when $B_z>0$ indicates that sporadic bursts of plasma fluxes, with convection toward the sun, are observed on the nightside and the dayside of both caps (regardless of season). The bursts are apparently due to the irregular nature of the recoupling of magnetic fields at higher latitudes or to the development of MHD instabilities. The characteristic transverse scales of the tubes of force convecting toward the sun at ionospheric altitudes are hundreds of kilometers long. The plasma flux in such formations has an eddy structure. Figures 4, references 16: 4 Russian, 12 Western.

UDC 551.521.8

Wave and Particle Interaction in Earth's Radiation Belts According to Intercosmos-19 Data

18660140f Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 10 Mar 87) pp 84-88

[Article by V. I. Larkina, Yu. V. Mineyev, and I. I. Senchuro]

[Abstract] Preliminary findings are presented for simultaneous measurements of geomagnetic field components in the inner radiation belts that were made by the "Intercosmos-19" satellite during geomagnetic disturbances in March and April 1979. The satellite's equipment was used to measure the amplitudes of the magnetic and electrical components of the field of ELF emissions in the 0.1-16 kHz range, electron fluxes in the 0.1-2.0 MeV range, and the geomagnetic field. The measurements were made during the magnetic storms of 9 March (SC 23.23 UT, $D_{st\max}$ = -129 nT, 10 Mar 2300 UT), 3 April (SC 10.02 UT, $D_{st\max}$ = -197 nT, 4 April 0400 UT), and 24 April (SC 23.57 UT, $D_{st\max}$ = -148 nT, 25 April 1500 UT). Periods were observed in which the amplitude of the magnetic component was weakly dependent on the L shell, and the electrical component grew by several factors for all frequencies simultaneously. The flux of highly energetic electrons in this region began to drop. The measurements confirm the possibility of excitation of low-frequency electromagnetic waves. Spectral analysis of the fluctuations identified several characteristic periods in the magnetic field and the intensities of low-frequency emissions and energetic electron fluxes. Figures 2, references 10: 8 Russian, 2 Western.

UDC 550.385.41

Structure of the Mid-Latitude Trough in the Nighttime Outer Ionosphere

18660140g Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 1 Jul 87) pp 89-93

[Article by L. D. Sivtseva (deceased) and V. A. Yershova]

[Abstract] Mid-latitude troughs are examined for altitudes of 500-1000 km in the nighttime winter ionosphere, where O^+ and H^+ concentrations are comparable in magnitude. The fact that the trough in each of the components in this region has its own nature makes the structure of the trough in the region's total ion concentration complex. Experimental data are analyzed that recorded the mid-latitude trough in the distribution of O^+ and H^+ concentrations that were measured by the mass spectrometer aboard the Oreol-2 satellite during January and February 1974, when solar activity was at a minimum ($F_{10.7}$ was approximately equal to 70-80). O^+ and H^+ concentrations were measured every 6 hours, making the spatial resolution by latitude about 0.5°. Latitude and trough shape in either the electron or the total ion concentration are found to be functions of the relative O^+ and H^+ content. In winter, in the nighttime outer ionosphere, the trough in the H^+ concentration always begins at the smaller L shells, which means that it is always wider than the O^+ trough. The H^+ concentration at the equatorial edge of the trough is always larger than at the polar edge and can have a stepped structure. The O^+ trough is characterized by a relatively smooth diminution of concentration at the equatorial edge and a sharp increase at the polar wall. The concentration minimum is most often observed as one approached the wall. At the wall itself, the O^+ concentration is considerably higher than the H^+ concentration. Figures 2, references 7: 3 Russian, 4 Western.

UDC 581.521

Interrelationship of Spatial, Angular, and Energy Distributions of Particles at Geosynchronous Orbit

18660140h Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 17 Jul 87) pp 94-101

[Article by N. A. Vlasova, A. S. Kovtyukh, M. I. Panasyuk, S. Ya. Reyzman, E. N. Sosnovets, O. S. Grafodatskiy, Sh. N. Islyayev, A. G. Kozlov]

[Abstract] In an effort to ascertain the quantitative relationships between energetic particles during magnetically quiet periods, the authors used the data of two geostationary Gorizont communications satellites (1984-78A and 1985-07A) to compare the spatial, angular, and spectral characteristics of the particles. The first satellite was equipped with a differential proton spectrometer that measured ion fluxes with energies of roughly 30-300 keV in 8 uniform channels. The aperture axis was aimed perpendicular to the plane of the geographic equator. The 1985-07A satellite was equipped with an ion spectrometer that was partially selective in terms of ion mass and charge. Its axis was parallel to the plane of the geographic equator along a line between the satellite and the Earth. Angular aperture for both spectrometers was about 10°. The researchers studied the diurnal variations of fluxes of protons (E approximately equal to 62-210 keV) in the context of drift approximation (when the μ and J adiabatic invariants are taken to be preserved, while the Φ is not). Although the theory of the motion of the particles has been studied in detail in

an azimuthally asymmetric magnetic field in which all three invariant are preserved, the authors found it unsuitable for their purposes, because particles with fixed energy E and fixed direction of velocity relative to the plane of a geosynchronous orbit have different μ, J, and Φ values at various points of a geosynchronous orbit. The authors were able to divide diurnal variation into two independent parts—one linked to anisotropy of pitch-angle distribution of particle, the other to hardness of energy spectrum—and they established a link between diurnal variation (day-night amplitude variations) and the spectral and angular characteristics of the particle fluxes in stationary conditions. Figures 2, references 17: 8 Russian, 9 Western.

UDC 550.388:537.221

Basic Geophysical Patterns of Electrization of Geosynchronous Gorizont Communication Satellites

18660140i Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 5 May 87) pp 102-112

[Article by Yu. I. Bakulin, O. S. Grafodatskiy, V. I. Guselnikov, V. I. Degtyarev, G. A. Zherebtsov, Sh. I. Islyayev, A. A. Kocheyev, O. I. Platonov, G. V. Popov, and L. L. Frumin]

[Abstract] Electrostatic charging, or electrization, of a high-orbit spacecraft is a complex process whose study is imperative not only for purposes of improving the accuracy of on-board measurements of radiation conditions near the spacecraft, but also for purposes of the ensuring the safe and proper operation of the spacecraft itself. In attempting to determine the general patterns of the diurnal variation in the electrization of spacecraft in geosynchronous orbit, as well as the intervals and reproducibility of such variations, the authors set out to establish the relationship between disturbances in diurnal electrization and magnetospheric disturbances. Experimental data were taken from September 1984 measurements of electrostatic fields (E) on the surface of two identical Gorizont spacecraft (Gorizont-8 and Gorizont-10). During the measurements, both spacecraft were at a geocentric distance of about 6.6 earth radii, a latitude of about 0°, and longitudes of 90° and 80°, respectively. E measurements were made every 330 seconds within a range of plus or minus 300 kV/m for all sensors, whose error did not exceed 20-30%. Both spacecraft were found to have a characteristic diurnal periodicity in terms of the variation in surface electrostatic fields. The behavior of the field on one spacecraft differed considerably from that of the other. Electrization features tied to local time were associated with changes in conditions involving illumination of the spacecraft with solar UV and x-ray radiation. Irregular disturbances in the electrostatic fields were linked to disturbances in near-satellite plasma during magnetospheric substorms. It was found that the surface electrostatic fields do not react in a clear way with passages through the plasmapause and edge of the plasma sheet. The substorm disturbances of electrization that were observed near local midnight coincide with geomagnetic coil-like disturbances and bursts of riometric absorption at ground-based stations near the magnetically coupled projections of the spacecraft. Magnetospheric disturbances were judged to be an important factor in electrization patterns on the spacecraft surfaces. Figures 4, references 11: 2 Russian, 9 Western.

UDC 537.591.4.574.83

Efficiency of Liberation of Nonrelativistic Flare Electrons From Simultaneous Observations of Bursts of Hard X-Ray Radiation and Solar Cosmic Ray Events

18660140j Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 9 Sep 88) pp 113-125

[Article by Ye. I. Daybog, Viktoriya Kurt, Yu. I. Logachev, and V. G. Stolpovskiy]

[Abstract] The article is part of a series of articles based on simultaneous observations of hard x-radiation (X_h) and energetic particles made in 1981-1982 by the Venera-13 and Venera-14 spacecraft. The purpose of the work reported here was to determine the coefficient of liberation of nonrelativistic electrons in solar flares in a wide range of power levels—from subflares to 3B flares. The authors also examined weak solar events that are accompanied by particle and quantum fluxes that are close in magnitude to equipment threshold sensitivity. Results of measurements of fluxes of X_h radiation and electrons in comparable energy intervals (E_X>55 keV and E_e>70 keV, E_X>125 keV and E_e>170 keV) were used to assess the coefficient of liberation. A solar cosmic ray event and an X_h burst were considered part of the same flare if the intensity of nonrelativistic electrons began to grow no more than 20-40 minutes after the burst began. Only those events that were associated with central and western flares were examined, which precluded heliolongitudinal dependence of the fluxes. The researchers limited their examination to time intervals in which the spacecraft were less than 45° away from the line running between the Earth and the sun. Electron density was measured once every 20 minutes in 6 differential channels in the energy interval of E_e = 25-1600 keV. The researcher concluded that the efficiency of liberation is a function of the height of a solar flare. Accordingly, in addition to event observed in X_h radiation and in solar cosmic rays, there exist events without x-ray accompaniment, as well as flares observed in X_h radiation, but unaccompanied by solar cosmic ray electron densities that were much above background. Figures 7, references 16: 7 Russian, 9 Western.

UDC 612.014

Radiation Conditions Along Flight Paths in Near-Earth Space at Moderate Altitudes

18660140k Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 21 Dec 87) pp 146-149

[Article by O. I. Savun and B. Yu. Yushkov]

[Abstract] Using a numerical model of the distribution of charged particle fluxes in near-Earth space, the researchers calculated the radiation conditions for a circular orbit with an altitude of H = 600 km and an inclination to the equatorial plane of $\varphi = 82°$ for 1987. Solar cycle variations were figured in. The orbit was not chosen randomly: it, along with orbits with H = 300 km, is one of the most typical orbits in use. Since the numerical model for the flux distribution consists of averaged electron and proton fluxes, the predicted values represent the most probable values at given orbital points. The rms spread of the true flux values and those of the model are plus or minus 20% for protons with energies of 30-100 MeV; plus or minus 30% for protons of 10-30 MeV and 100-400 MeV; and up to plus or minus 50% for protons with energies of 1-10 MeV. Similarly, the rms deviation for predicted electron fluxes is up to plus or minus 50% for energies of 0.5-2 MeV and is greater by a factor of 2-3 for energies outside that range. Figures 4, references 2 (Russian).

UDC 520.2

First Star Observations Using 'Graf-1' Adaptive Telescope

18660108 Kiev KINEMATIKA I FIZIKA NEBESNYKH TEL in Russian Vol 4 No 5, Sep-Oct 88 (manuscript received 22 Jun 87) pp 88-90

[Article by E. A. Vitrichenko, V. V. Voytsekhovich, P. A. Znykin, A. V. Lamanov, A. A. Pimonov, Yu. A. Roze and A. N. Tsagolov, Space Research Institute, USSR Academy of Sciences, Moscow]

[Abstract] Only two previous communications on observations of stars using an adaptive telescope have been published. This article gives the first preliminary results of research on the capabilities of the "Graf-1" adaptive telescope at the Southern Station of the State Astronomical Institute. The "Graf-1" is intended for compensation of image trembling and in essence is a photo guide (a schematic diagram of the telescope accompanies the description). A standard Zeiss telescope (D = 60 cm, F' = 7.5 m) is used. A plane-parallel plate 5 mm thick is mounted in the convergent beam; it is held in a Cardan joint which is moved by stepped motors. Behind the telescope focus there is a microobjective, a translucent plate which transmits the reflected light to a camera. The transmitted light is focused on the photocathode of a quadrant light detector. The signal from this detector is fed to a group of four pulsed amplifiers and then to registers and a device for control of the stepped motors. The diagram and description serve as a basis for a discussion of the telescope operating principle. The exclusive purpose of observations with the "Graf-1" was checking of its performance. Very simple experiments are described. It was found that the adaptive system completely eliminates the error is guiding the telescope. Image quality improves appreciably when adaptation is activated. Guidance errors were compensated and the image was improved by a factor of 1.3 at the 50% level. A number of problems remain to be solved and significant image statistics must be obtained with different image qualities in order to make a final evaluation of instrument capabilities. Figures 4; references: 3 Russian.

UDC 523.985

Theory of Fine Structure of Solar Type-IV Radio Bursts

18660109a Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 65 No 5, Sep-Oct 88 (manuscript received 26 Dec 86) pp 1058-1066

[Article by V. V. Fomichev and S. M. Faynshteyn, Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences; Gorkiy Polytechnic Institute]

[Abstract] The process of interaction of Langmuir waves and whistlers in the solar corona is examined within the theory of weak turbulence. It follows from the conservation laws that Langmuir waves and whistlers with wave vectors approximately equal and oppositely directed participate in such interaction and the forming electromagnetic radiation corresponds to a wave of the ordinary type. Shortened equations are derived for the amplitudes and intensities of interacting waves. The formulated theory is used in interpreting the fine structure of the filaments type observed in type-IV radio bursts. The intensity of the filaments was used in estimating the turbulence level of whistlers in coronal magnetic arcs. Figures 3; references 18; 10 Russian, 8 Western.

UDC 523.45-77-56

Pulsed Generation of S-Bursts in Jovian Decameter Radio Emission. Dynamics of Plasma Wave Conversion

18660109b Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 65 No 5, Sep-Oct 88 (manuscript received 1 Dec 86) pp 1067-1074

[Article by V. V. Zaytsev and V. Ye. Shaposhnikov, Applied Physics Institute, USSR Academy of Sciences]

[Abstract] A study was made of the dynamics of conversion of plasma waves at frequencies close to the electron gyrofrequency into electromagnetic radiation in the region of generation of S-bursts in the Jovian ionosphere. It is shown that the principal processes determining the dynamics of conversion and stabilization of the level of electromagnetic radiation are the process of scattering of

a plasma wave into an extraordinary electromagnetic wave on superthermal magnetized electrons with a nonzero mean velocity along the magnetic field and the process of scattering of a plasma wave into a plasma wave on nonmagnetized ions of equilibrium plasma. The level of electromagnetic radiation corresponding to the ordinary mode in this case is insignificant. The fact of predominance of an extraordinary mode in the electromagnetic radiation emanating from the source corresponds to actual observations. The conversion of plasma waves at the source has a fluctuating character, which makes it possible to explain the observable quasiperiodic sequence of narrow-band S-bursts. The parameters of a developing pulsating region, period and level of electromagnetic radiation, coincide in order of magnitude with the experimental data. Figure 1; references 16: 7 Russian, 9 Western.

UDC 523.22

Times of Evolution of Planetismal Disks

18660109c Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 65 No 5, Sep-Oct 88 (manuscript received 4 Sep 86, after revision 5 Jul 87) pp 1075-1085)

[Article by S. I. Ipatov, Applied Mathematics Institute, USSR Academy of Sciences]

[Abstract] Important conclusions are drawn concerning the process of accumulation of planets. Section 1 describes the evolution of disks of bodies moving about a massive central body (sun). Emphasis is on models in which the bodies are merged during collisions, but the influence exerted on the accumulation process by the fragmentation of bodies and gas resistance is also examined. The relative gravitational influence of bodies is taken into account by the spheres method, that is, within a sphere the relative motion of bodies is examined within the framework of the two-body problem, whereas outside a sphere the bodies move about the sun in unperturbed Keplerian orbits. Section 2 examines some general problems in writing of an algorithm for computer simulation of the evolution of disks consisting of a large number of bodies. As in earlier studies the bodies of the disk are broken down into groups, but the interactions of bodies are taken into account differently. At the limit, when each group consists of a single body, this algorithm coincides with the algorithm used in investigating the evolution of disks consisting of hundreds of bodies. The formulas used for determining the number of convergent bodies and the number of collisions of bodies during a given time were derived for a more complex model than the "particle in a box" model and make it possible to take into account not only the relative velocity of the bodies, but also the orbital elements of the convergent bodies. The times for falling of small bodies onto larger bodies are determined in Section 4 for models differing from the models used by Safronov, et al. Section 5 gives the time of evolution of disks initially consisting of hundreds of bodies. The results given in Sections 3 and 5 are used in Sections 6 and 7 for a number of models in estimating the evolution time for disks consisting of a large number of initial bodies. A plane model is also studied, making it possible to evaluate the minimal changes in orbits of gravitationally interacting planetismals. References 23: 11 Russian, 12 Western.

UDC 324.352

Detection of Hard Component of Radiation in Spectrum of X-Ray Nova in Constellation Vulpecula. Preliminary Results From 'Kvant' Module

18660113 Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 14 No 9, Sep 88 (manuscript received 13 Jun 88) pp 771-786

[Article by R. A. Syunyayev, I. Yu. Lapshov, S. A. Grebenev, V. V. Yefremov, A. S. Kaniovskiy, D. K. Stepanov, S. N. Yunin, Ye. A. Gavrilova, V. M. Loznikov, A. V. Prudkoglyad, V. G. Rodin, O. P. Babushkina, S. V. Kiselev, A. V. Kuznetsov, A. S. Melioranskiy, A. Smith, A. Parmar, W. Pietsch, S. Doebereiner, J. Engelhauser, C. Reppin, J. Truemper, W. Voges, E. Kendziorra, M. Maisack, B. Mony and R. Staubert, Space Research Institute, USSR Academy of Sciences, Moscow; Technical Center, European Space Agency, Noodrwijk, Netherlands; Exoatmospheric Physics Institute, Max Planck Society, Garsching, West Germany; Astronomical Institute, Tubingen University, West Germany]

[Abstract] An X-ray nova was discovered in the constellation Vulpecula on 26 April 1988. Its emission spectrum was close to the spectrum of bremsstrahlung of optically thin plasma with a temperature of 20 million degrees. Observations of this bright object were initiated by the "Rentgen" observatory on the "Kvant" module on 15 May. The first observations revealed two components: soft and hard. The hard component corresponds to temperatures of about a billion degrees if evaluated in the approximation of bremsstrahlung of optically thin plasma. The soft component dominates in the 4-15 keV band and contributes 90% of the source luminosity. The hard power law component dominates in the 15-200 keV band. The preliminary results of analysis of the emission spectrum jare given. The presence of an exceedingly soft component and a relatively long lifetime of the source shows that this object is a so- called "soft nova." The detection of a hard tail and the totality of optical and radio data indicate that this is a real candidate for a black hole, in many respects similar to the known source Cygnus X-1. Twenty-five observations were made during the period 15 May-8 June. The results of observations with the GSPS, "Pulsar-X-1" and "Hexe" instruments are given separately. The appearance of the X-ray nova in Vulpecula confirmed the presence of an individual subclass of "soft" X- ray transients characterized by a powerful soft component in the spectrum, a hard emission tail, a characteristic lifetime of about a month and

having optical objects with an exceedingly low luminosity as companions. During flaring of the X-ray nova the optical brightness of the system increases due to X-ray heating of the surface of a normal star and optical radiation of the outer zones of the accretion disk. All these data indicate that the nova in Vulpecula is a very interesting object for further research. Figures 7; references 22: 4 Russian, 18 Western.

UDC 524.64

Periodic (Diurnal Range) Sources of Hard X-Radiation Near Galactic Center According to Experimental Data From 'Prognoz-9' Artificial Earth Satellite

18660114 Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 14, No 10, Oct 88 (manuscript received 14 Apr 88) pp 893-901

[Article by M. I. Kudryavtsev, Yu. I. Logachev and S. I. Svertilov, Nuclear Physics Institute, Moscow State University imeni M. V. Lomonosov]

[Abstract] Apparatus containing an x-ray instrument and background detectors of charged particles was used during the period 1 July 1983 through 14 February 1984 on the "Prognoz-9" station in a high-apogee (720,000 km) orbit for carrying out a multipurpose experiment which included research on periodic sources of hard x-radiation (10-200 keV). Extensive regions of the sky were observed: the region near the Galactic anticenter, sectors of the sky distant from the Galactic equator, and the region near the Galactic center. A large field of view and constant orientation of the x-ray instrument on the sun enabled a slow scan in the course of the experiment along a broad band of the star sky (50° on either side of the line of the ecliptic). Variations of x-radiation of different kinds were registered during intersection of the Galactic center. An analysis by the method of superposition of epochs made it possible to detect a periodic process which was known earlier (82 hours) and processes not observed earlier (62, 67, 98 and 152 hours). The new periodic sources observed in the experiment are characterized by periods which can be classified as diurnal. By analogy with the source 4U 1700-37, these periods can be considered orbital. Sources with periods in the diurnal range are usually interpreted as massive binary systems containing a neutron star. About 20 such objects have now been discovered. Since the emissions of x-ray binaries are highly variable, extremely long continuous observations of a single source are required for detection of periodic processes. The observation regime in this experiment made it possible to carry out continuous observations of a single source for two months, creating favorable conditions for the discovery of new periodic processes. Figures 3; references 7: 1 Russian, 6 Western.

UDC 524.352

Acceleration of Rotation of X-Ray Pulsar Hercules X-1. Results of Observations by 'Kvant' Module in August 1987-July 1988

18660115 Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 14, No 11, Nov 88 (manuscript received 5 Aug 88) pp 979-991

[Article by R. Syunyayev, M. Gilfanov, Ye. Churazov, V. Loznikov, V. Yefremov, A. Kaniovskiy, A. Kuznetsov, A. Melioranskiy, W. Voges, W. Pietsch, S. Doebereiner, J. Engelhauser, C. Reppin, J. Truemper, H. Oegelman, E. Kendziorra, B. Mony, M. Maisack, R. Staubert, A. Smith and A. N. Parmar, Space Research Institute, USSR Academy of Sciences, Moscow; Exoatmospheric Physics Institute, Max Planck Society, Garsching, West Germany; Astronomical Institute, Tubingen University, Tubingen, West Germany; Technical Center, European Space Agency, ESTECH, Noordwijk, Netherlands]

[Abstract] Between August 1987 and July 1988, the "Rentgen" observatory on the "Kvant" module was used in making several series of observations of the x-ray pulsar Hercules X-1: on 13-15 August 1987, 21 May 1988, and 25 July 1988. This article gives data on the period of x-radiation pulsations measured with a gas scintillation proportional counter and a Hexe instrument. Data are given on the pulse profile for energy ranges of 12-20 keV, 20-30 keV, 30-40 keV, 40-50 keV and 50-60 keV; on quasistationary acceleration and slowing regimes; and on brief stages in acceleration and slowing of rotation. Certain figures give the results of determination of x-radiation pulses during 1972-1988; pulse profiles for this source in different energy ranges in 1987 and 1988; rate of change in period as function of time interval between measurements. A table gives the results of period determinations made from 1971 to 1988. A comparison of "Kvant" data with the preceding observations indicated that, during 1984-1988, Hercules X-1 was in a regime of quasistationary acceleration similar to that observed in 1972-1978. Figures 6; references 28: 2 Russian, 26 Western.

UDC 539.1+533.951

Relativistic Surfing in Inhomogeneous Plasma and Cosmic Ray Generation

18660119a Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 15 No 1, Jan 89 (manuscript received 11 Oct 88) pp 3-10

[Article by N. S. Yerokhin, S. S. Moiseyev and R. Z. Sagdeyev, Space Research Institute, USSR Academy of Sciences, Moscow]

[Abstract] The most probable places for generation of high-energy galactic cosmic rays are remnants of supernovae, where according to recent studies the maximal energy of accelerated particles is estimated at about 10^{12}eV/nucleon. However, the problem of the origin of

galactic cosmic rays with greater energies remains open. Research now indicates that the transformation of electromagnetic radiation on a plasma density gradient results in the excitation of strong plasma waves in narrow layers of hybrid resonances. These waves are capable of trapping charged particles in a potential well and as a result of resonance interaction can accelerate them in short distances to high energies by the surfatron mechanism. A universal differential spectrum of fast particles was obtained in a simple acceleration model. Under astrophysical conditions such surfing gives a new solution of the problem of the origin of cosmic rays with an energy exceeding that attributable to origin in remnants of supernovae. This approach is extremely promising for further investigations, especially in determining the energetics of a source of strong plasma waves and the parasitic influence of instabilities in the system cosmic rays + plasma + strong plasma wave. References 30: 14 Russian, 16 Western.

UDC 523.98

Influence of Collective Effects on Nonthermal X-Radiation of Solar Flares

18660019b Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 15 No 1, Jan 89 (manuscript received 29 Dec 87) pp 70-74

[Article by V. D. Ivanov and L. G. Kocharov, Leningrad Polytechnic Institute imeni M. I. Kalinin]

[Abstract] The classical model of a thick target employed in the interpretation of bursts of flare X-radiation takes into account only individual (collisional) energy losses of accelerated electrons during their propagation in solar atmosphere plasma. New observational data, however, indicate that the concentration of accelerated electrons in the flare region is quite great, and therefore the need arises for an examination of collective effects. It is shown that the collective deceleration of nonthermal electrons in the electrical field of a stable return current and ionization of the upper layers of the chromosphere under the influence of accelerated electrons can exert a substantial influence on the form of the spectrum of nonthermal X-radiation of solar flares. Radiative cooling stabilizes temperature, whereas the isotropization of accelerated electrons during scattering and collisional attenuation of Langmuir waves results in the suppression of beam instability. As a result, in a stationary state the intensity of X-radiation in the energy range 10-50 keV is substantially less than indicated by the classical thick target model. Figures 2; references 12: 4 Russian, 8 Western.

Lunar Magnetic Fields

18660119c Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 15 No 1, Jan 89 (manuscript received 1 Aug 88) pp 89-94

[Article by A. Z. Dolginov, Physical Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad]

[Abstract] Direct measurements have revealed the presence of constant small-scale magnetic fields on the lunar surface. A correlation has been established between gravity and magnetic anomalies, evidence of a deep source of these anomalies. The lunar bedrocks have a stable remanent magnetization which usually arises if the rocks are crystallized, having cooled in an external magnetic field. This can be indicative of the existence of a relatively strong magnetic field in the early stage of lunar evolution. After an analysis of different published hypotheses, it is postulated that the observed local (about 100 km) magnetic fields (about 10^{-4})gauss) in the early stages of lunar evolution were fields associated with inhomogeneities of the temperature and composition of internal sectors of the moon. The applicability of these findings to the Earth is examined. It is shown that a similar nonuniformity at the Earth's core-mantle boundary could make a contribution to the terrestrial magnetic field. References 15: 9 Russian, 6 Western.

UDC 521.1

Distant Satellite Orbits in Restricted Circular Three-Body Problem

18660135a Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 1 Apr 87) pp 813-818

[Article by A. Yu. Kogan]

[Abstract] "Distant satellite orbits" are those separated from a body lesser in mass by distances considerably exceeding the radius of the Hill sphere. The need for such orbits arises, for example, in the planning of expeditions to the natural satellites of planets since their bodies often occupy a large part of the Hill sphere and sometimes virtually all of it. Orbits of this same class are also necessary for a number of orbital astrophysical observatories which must be at considerable distances from the Earth. Retrograde periodic Hill orbits belong to the discussed class. Plane orbits of this class were examined by D. Benest (CEL. MECH., Vol 13, No 2, 1976). This article gives an analysis of a more general three-dimensional case, giving a description of such orbits and their long-period evolution, followed by a study of stability conditions. The analytical estimates are in good agreement with the results of numerical integration of the equations of the three- body problem. Figures 4; references 6; 5 Russian, 1 Western.

UDC 521.1

Periodic Solutions in Neighborhood of Triangular Libration Points in Restricted Elliptical Three-Body Problem

18660135b Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 25 May 87) pp 819-829

[Article by A. Ikromov and E. M. Mukhamadiyev]

[Abstract] This is essentially a continuation of an earlier study by A. Ikromov entitled "6π-Periodic Solutions of the Plane Restricted Elliptical Three-Body Problem" in

ASTRON. ZHURN., Vol 4, pp 800-805, 1984. It is shown that the equations of the restricted elliptical three-body problem with definite values of the mass parameter and small eccentricity values allow periodic solutions in the neighborhood of the triangular libration points different from these points. References: 9 Russian.

UDC 629.783.062.2

Periodic Motions of Satellite With Strong Magnet in Polar Orbit Plane With Allowance for Perturbations

18660135c Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 15 Jan 87) pp 830-839)

[Article by V. A. Sarychev, M. Yu. Ovchinnikov and A. D. German]

[Abstract] The motion of an axisymmetric satellite with a strong magnet in a polar orbit plane is examined. Allowance is made for the effect of the restoring magnetic moment and perturbing aerodynamic and gravitational moments. The Poincare method is used in investigating periodic satellite motions. Formulas are derived for determining the branch points of these motions. The influence of perigee position, orbital eccentricity and other system parameters on the characteristic periodic motions of the satellite are investigated. Within the framework of a model formulation this study defines the influence of different parameters on the magnetic orientation mode. An increase in orbital eccentricity and the aerodynamic parameter of the satellite usually results in an increase in oscillations of the longitudinal axis of the satellite relative to H. However, there are intervals of change in the perigee argument for which the dependence of amplitude on eccentricity is the reverse. If orbital perigee is situated near the equator and the satellite enters the dense layers of the atmosphere with its "tail" forward (unstable with respect to the aerodynamics of configuration), the aerodynamic perturbations partially compensate the perturbations caused by change of the H vector along the orbit and orbital eccentricity. The values of the parameters of the problem in whose neighborhood there is an increase in oscillations and periodic motions in the orbital plane or spatial periodic motions arise, are determined. Figures 6; references 10: 8 Russian, 2 Western.

UDC 531.38

Lifetime of Artificial Earth Satellites

18660135d Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 15 Jan 87) pp 855-860)

[Article by B. N. Noskov]

[Abstract] A study was made of satellites moving in an intermediate orbit based on solution of the generalized problem of two fixed centers. Solution of the problem is complicated because it is impossible to use expressions derived earlier for changes of intermediate elements since in actual practice these relations are most effective for short time intervals. The integration of the differential equations for elements of an intermediate satellite orbit must therefore be carried out under the condition that the elements themselves entering into the right-hand sides of these equations are functions of time. It is then possible to derive the necessary analytical relations which make it possible to investigate evolution of orbital elements under the influence of atmospheric braking over a prolonged time interval (on the order of several months), and as a result, to determine the remaining lifetime of satellites. References; 5 Russian.

UDC 535.24:523.42

Dependence of Transmission Functions on Temperature in Problem of Thermal Sounding of Planetary Atmosphere

18660135e Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 12 May 88) pp 861-867

[Article by Ye. A. Ustinov]

[Abstract] A nonlinear operator dependence relating the vertical variation of the transmission function for the gas atmosphere at a stipulated frequency and the vertical temperature profile in the atmosphere was investigated. In a linear approximation this dependence is reduced to an integral form in which the dependence of the gas absorption coefficient on temperature is discriminated in explicit form. The derived relation is used in proposing a simple scheme for interpolating the dependence of the transmission function on temperature at thermal sounding working frequencies. An example is given illustrating the retrieval of the temperature profile on the basis of thermal sounding data with use of the proposed interpolation scheme. Figures 4; references 8: 7 Russian, 1 Western.

UDC 551.510.536

Contribution of Photoelectrons to Excitation and Ionization Under Influence of Source of Ultraviolet Radiation on Atmosphere

18660135f Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 25 Jun 88) pp 868-873

[Article by Yu. M. Grishin, N. V. Yeliseyev, V. A. Kiselev and S. I. Kozlov]

[Abstract] Two main mechanisms must be taken into account when computing the chemical composition of the atmosphere arising under the influence of a source of ultraviolet radiation: direct ionization, dissociation and excitation processes as a result of absorption of radiation quanta and collisions with photoelectrons forming as a

result of the exposure. The first mechanism was examined by the authors in KOSMICH. ISSLED., Vol 26, No 4, p 614, 1988. This article examines the additional effects caused by photoelectrons in the ionization and excitation of upper atmosphere components. It is shown that there is a fundamental possibility of the formation of new excited particles in comparison with the processes of photoabsorption of radiation quanta. In comparison with direct photoabsorption, photoelectrons can make a substantial contribution only to the formation of metastable components. The data obtained in the two studies make it possible to refine the requirements on the parameters of the source necessary for the realization of different effects. Figures 3; references 10: 9 Russian, 1 Western.

UDC 550.388.2

Radiation of Electromagnetic Waves by Modulated Electron Beam Injected Into Ionosphere Along Magnetic Field

18660135g Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 24 Feb 87) pp 874-880

[Article by N. Ya. Kotsarenko, G. V. Lizunov and A. A. Silivra]

[Abstract] The spectrum and intensity of spontaneous radiation of electron pulses injected into ionospheric plasma along the geomagnetic field were computed. It is assumed that a real beam has the configuration of a highly corrugated cylinder. It is precisely the beam corrugation which is responsible for the excitation of counter whistlers and fast electromagnetic waves in the gyrofrequency harmonics. The motion of electron pulses in ionospheric plasma is accompanied by the excitation of waves in different frequency ranges. As a result of periodic modulation of the injector current an equidistant frequency current, strictly speaking, is excited, but in cases of practical interest it can be considered quasi-continuous. The intensity of the excited waves is proportional to the square of the modulation frequency, as is characteristic for the radiation of a linear current. The results for radiation of the fundamental spatial harmonic of the electron current in the whistler range is in qualitative agreement with results obtained earlier (K. J. Harker, et al., RADIO SCI., Vol 19, No 2, p 454, 1984). The radiation of the higher spatial harmonics in the whistler and plasma frequency ranges is 3-4 orders of magnitude less than the radiation intensity of the fundamental harmonic. In the high- frequency range the form of the electron beam is of decisive importance. In this frequency range the radiation is attributable only to the periodicity of beam form. Figures 2; references 9: 7 Russian, 2 Western.

UDC 581.521

Ionic Ring Current During Time of Magnetic Disturbances Determined From Observations in Geostationary Orbit. 3. Variations of Ionic Composition Associated With Weak Magnetic Disturbances

18660135h Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 22 Apr 87) pp 881-889

[Article by N. A. Vlasova, A. S. Kovtukh, M. I. Panasyuk, E. N. Sosnovets, O. S. Grafodatskiy, Sh. N. Islyayev and A. G. Koslov]

[Abstract] Experimental data on variations of fluxes of H^+, $[N, O]^{2+}$ and $[C, N, O]^{4+}$, obtained on the geostationary communications satellite "Gorizont" (1985-07A) during and after weak magnetic disturbances (with amplitudes of D_{st} variations less than several tens of nT), are analyzed. These disturbances had active phases prolonged in comparison with magnetic storms. The dynamics of the relative content of ions was investigated. After two weak geomagnetic disturbances of 19-20 February and 7 March 1985 there was a change in the ion composition of the ring current in the energy range about 50-120 keV/e characterized by an increase in the relative content of heavy ions of both solar and ionospheric origin. In addition to disturbances of this type, examples are given of disturbances during which changes in ion composition were present similar to those described earlier when the main components of the injected ring current were H^+ ions and ionospheric ions $[N, O]^{2+}$. It is postulated that prolonged magnetically quiet periods of time should result in a gradual increase in the relative concentrations of heavy ions subjected to more effective acceleration than protons in the process of circulation on the periphery of the magnetosphere. However, a decrease in the activity of ionospheric acceleration mechanisms during this period results in an increase in the relative content of the solar component. This process should continue to the onset of an increase in substorm activity when the composition of the ions can experience substantial changes due to replenishment of the ion ring current for the most part by the ionospheric component. Figures 3; references 10: 5 Russian, 5 Western.

UDC 551.510.535.2

Electrodynamics of Morning Sector of Auroral Oval

18660135i Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 29 Dec 86) pp 890-899

[Article by E. M. Dubinin, P. L. Izraylevich, N. S. Nikolayeva, I. M. Podgornyy, A. K. Kuzmin, A. N. Zaytsev and V. G. Petrov]

[Abstract] A study was made of different types of electrical and magnetic fields in the morning sector of the auroral ionosphere on the basis of the results of measurements on the "Intercosmos-Bolgariya-1300" satellite.

The satellite data are compared with surface observations of geomagnetic variations. It was found that in the morning sector in the upward current region there is a considerable increase in the energy flux and the mean energy of leaking electrons. As a result, there is a marked increase in the Hall and Pedersen ionospheric conductivities in zone 2 of the longitudinal currents in the morning sector. The ionosphere is an electrical load for the generator situated in the magnetosphere. An increase in ionospheric conductivity exerts a weak influence on the distribution of longitudinal currents and results in a decrease in the electrical field in the zone of increased conductivity. The resistance of the part of the electrical circuit situated in the magnetosphere considerably exceeds the resistance of the ionospheric part, that is, the ionosphere is connected to the current generator. Depending on the conditions for the leakage of electrons, the electrical field in the morning oval may be distributed differently. The electrical field maximum can be situated either in zone 1 of longitudinal currents (current downward) or between two large-scale layers of longitudinal currents. When there is a stratification of the main large-scale system of longitudinal currents (zones 1 and 2) into several pairs of lesser- scale currents, the distribution of the electrical field in each pair of currents is similar to its distribution for large-scale currents. The position of the westerly electrojet relative to layers of longitudinal currents varies as a function of the distributions of the electrical field and ionospheric conductivity: the center of the electrojet may be situated between zones 1 and 2 of the longitudinal currents and be displaced into zone 2. A southward-directed strong electrical field responsible for the flow of the westerly electrojet arises in the tail due to the polarization of plasma under the influence of the Lorenz force and is projected along the magnetic field lines into the auroral zone. Figures 6; references 15: 1 Russian, 14 Western.

UDC 551.521.6

Observations of Bursts of Long-Wave Radio Emission During Powerful Chromospheric Events

18660135j Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 11 Mar 87) pp 900-909

[Article by V. P. Grigoryeva and V. S. Prokudina]

[Abstract] The results of analysis of bursts of long-wave radio emission in the frequency range 2160-540 KHz are given. These data were registered on the "Prognoz-2" satellite in April-May 1981 and were related to the development of solar chromospheric flares. On the basis of the lag time of bursts of long-wave radiation relative to the explosive phase of bursts all the observed events can be divided into three principal groups. 1. Type-III bursts which have no lag relative to the explosive phase of a flare and are a continuation of type-III bursts in the meter radio range. This type of burst with a rapid frequency drift is associated with the motion of high-energy electrons along open magnetic lines of force at great distances from the sun. 2. Type-SA bursts, caused by the acceleration of electrons at the shock wave front passing through the corona and formed during a flare. This type of burst is a continuation of a type-II HB burst in the kilometer range and may be delayed relative to the explosive phase of the flare. In powerful events there is a complex form of a burst of the III + SA type when a type SA burst follows a type-III burst. 3. Events which are characterized by an absence of bursts of long-wave radio emission during powerful flares. Such events may be observed in cases when there are closed magnetic configurations over an active region on the sun and there are no conditions for the escape of particles (electrons) accelerated in the flare into circumsolar space. Each of these groups is described in detail. Figure 1; references 23: 6 Russian, 17 Western.

UDC 531.352

Asymptotic Movements of Asymmetric Solid Body in Circular Orbit in Presence of Third-Order Resonance

18660135k Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 6 Jan 88) pp 943-944

[Article by S. D. Furta]

[Abstract] A study was made of the problem of motion of an asymmetric solid body whose center of mass moves in a Keplerian circular orbit in a Newtonian field of force. It has already been demonstrated that this problem allows positions of relative equilibrium of a body corresponding to a coincidence of the main central axes of inertia of the body and the axes of an orbital coordinate system. The stability of these positions of equilibrium has already been investigated. This article examines the existence of motions of a solid body tending to the considered positions of equilibrium with t tending to positive or negative infinity in a case when the chararacteristic frequencies of the linearized system ω_1, ω_2, ω_3 are related as $\omega_3 = 2\omega_1$ or $\omega_3 = 2\omega_2$. A solution is obtained in the form of two single- parameter families of motions of a body, one of which tends to relative equilibrium with t tending to positive infinity and the other with t tending to negative infinity. References 4: 3 Russian, 1 Western.

UDC 537.591

Nonstationary Potential of Space Vehicle Emitting Electrons Into Free Space

18660135l Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 23 Jun 87) pp 953-956

[Article by A. Yu. Bessarabskiy and Ye. G. Shustin]

[Abstract] Although the stationary potential of an ionospheric probe or space vehicle emitting electrons into surrounding space has been investigated in some detail,

the dynamics of potential accompanying pulsed beam injection has remained virtually unclarified despite a number of investigations which have resulted in a number of hypotheses explaining this phenomenon. This problem of the potential of an isolated body emitting an electron beam in rarefied gas has now been investigated by the method of qualitative analytical evaluations and a model experiment (both approaches are described in detail). The boundary of the perturbed region is simulated by a collector situated at a stipulated distance from the electron gun. This research confirmed the conclusion drawn by Z. Klos, et al. in COSPAR Report No 1.3.7 (26th Session) on the possibility of charging of the probe emitting electrons into rarefied plasma to a potential exceeding the accelerating voltage. The parameters of the experiment were such that some of the electrons were incident on the collector. The predictions of the theory developed for this case and the results of experimental measurements of electron gun potential are in good agreement with one another. Certain findings differ from those obtained by Klos, et al. due to different experimental conditions. Figures 3; references 4: 3 Russian, 1 Western.

UDC 521.85

Method for Recovering Radial Brightness Distribution Across a Stellar Disk From Speckle Interferometry Data and Use of the Method in Analyzing Observations of α Orion

18660137a Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 65, No 6, Nov-Dec 88 (manuscript received 5 Jan 87) pp 1187-1195

[Article by M. B. Bogdanov, Saratov State University]

[Abstract] The two variations of speckle interferometry generally used to measure the characteristics of binary systems either sacrifice information on the phase of the three-dimensional image spectrum or can be used for only the brighter stars. The two-dimensional brightness distribution across an object can be ascertained from speckle interferometry data, but noise presents serious difficulties. For recovering the radial brightness distribution across a stellar disk from the data of speckle interferometry, the authors here propose a method based on modern numerical methods for the solution of ill-posed problems. Underlying the method is the assumption that brightness distribution, derived by averaging the brighter speckles on many short-exposure images, is a two-dimensional convolution of brightness distribution across an object and the diffraction function of scattering of a point of the telescope. The method's use in the analysis of observations of α Orion yielded results that were in agreement with the data of independent interferometry. The brightness distributions found in the TiO absorption band and in the nearby continuum do not contradict the assumption of the presence near α Orion of a dust envelope inside the extended atmosphere. Figures 2, references 26: 11 Russian, 15 Western.

UDC 523.72-726

Solar Wind From Radio Occultation Data of Venera-15 and Venera-16

18660137b Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 65, No 6, Nov-Dec 88 (manuscript received 14 Apr 87) pp 1290-1299

[Article by O. I. Yakovlev, A. I. Yefimov, and S. N. Rubtsov, Institute of Radioengineering and Electronics, USSR Academy of Sciences]

[Abstract] Radio occultation has demonstrated its worth on a number of Soviet and U.S. space missions, yielding valuable information on solar wind. Venera-15 and Venera-16 bolstered the status of radio occultation in the probing of interplanetary and near-solar plasma by providing new data on solar wind parameters at distances of 5-100 solar radii. The two spacecraft emitted coherent signals in the decimeter and centimeter ranges at wavelengths of 32 and 5 cm in 196 sessions that totaled 650 hours. The greatest of acceleration of solar wind velocity was found at 12-25 solar radii. Electron density is elevated locally at 15-17 solar radii and 25-28 solar radii. Solar wind intensity is weakly dependent on distance at 5-15 solar radii; it increases by an order of magnitude at 15-25 solar radii and remains constant at 40-90 radii. Relative inhomogeneity of plasma increases sharply at 20-35 solar radii, remaining constant up to 90 solar radii. The index for the small-scale portion of the spatial spectrum of plasma inhomogeneities is 2.5 at 5-8 solar radii; it increases at 10-30 radii and remains constant at 3.7 at 35-90 radii. The spectral index of the large-scale portion of the spectrum of inhomogeneities does not vary with heliocentric distance (3.5). The representative minimum scale of inhomogeneities is 4 km at 6 solar radii, increasing to 24 km at 20 radii. Figures 6, references 23: 12 Russian, 11 Western.

UDC 523.42/43-852

Calculations of Limb Radiance of Venus and Mars in the IR CO_2 Band With Allowance Made for Disturbance of the Local Thermodynamic Equilibrium

18660137c Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 65, No 6, Nov-Dec 88 (manuscript received 20 Apr 87) pp 1300-1307

[Article by G. I. Stepanova and G. M. Shved, Leningrad State University]

[Abstract] Total intensities of atmospheric emissions were obtained in the vibration-rotation CO_2 bands at 1.2, 1.4, 1.6, 2.0, 2.7 and 4.3 μm for Venus and Mars. Calculations were performed for altitudes at which the rarity of molecular collisions results in a nonequilibrium population of vibrational states. Daytime limb radiance was derived for all six bands; nighttime radiance, for 4.3 μm. All daytime profiles showed a maximum at altitudes

at which local thermodynamic equilibrium was disturbed. The nighttime profiles demonstrated a sharp drop in lapse rate with altitude, which is due to the presence of a maximum in the population of vibrational states that results from the absorption of tropospheric thermal radiation in the 4.3 μm band. Figures 3, references 9: 5 Russian, 4 Western.

Results From Radio Astronomy Interferometer Complex

18660164 Moscow TASS in English 1837 GMT 18 Mar 89

[Article by TASS correspondent Mark Khabinsky]

[Text] Kharkov, March 18—Scientists of the Radioastronomy Institute of the Ukrainian Academy of Sciences have formed a hypothesis of an unknown pulsar, a mighty electromagnetic radiation source, existing in the Cassiopeia constellation. They recorded signals coming from the constellation which is almost 10,000 light-years away from earth. Nobody has received and deciphered signals from outer space from such a long distance with such clarity.

Two long-wave radio telescopes, built in the Kharkov region (Ukraine), helped scientists unveil mysteries of the universe. One of them, functioning near the village of Grakovo, is one of the world's largest. The total area of its antenna network is 150,000 square meters. Another one, comparatively small, was constructed near Gottwald. With 40 kilometers between them, they are linked with each other to form a single complex interferometer which increased the equipment's resolving power scores of times.

In the Cassiopeia constellation astronomers have observed cosmic plasma clouds covering a supernova star which appeared as a result of a celestial body explosion, director of the institute Leonid Litvinenko explained. But only now scientists have managed with the help of the new complex to register at a fantastically long distance a compact radio frequency radiation source which is measured at scores of kilometers.

The interferometer will bring into the integral system also the Odessa radio telescope which was recently built at the Black Sea coast. The new complex will also comprise the radio telescopes which are now under construction near Lvov and Poltava. The radio astronomical complex, which occupies an area of almost a thousand kilometers, is planned to be completed next year. It will increase the antenna network's capacity hundreds of times. Interacting telescopes have already helped explore over 30 radio galaxies, quasars and supernova stars. The prospects of the complex are even more impressive.

Soviet Mars Program

18660122 Moscow ZEMLYA I VSELENNAYA in Russian No 1, Jan-Feb 89 pp 19-26

[Article by Yu. I. Zaytsev, Space Research Institute, USSR Academy of Sciences, under the rubric "Space Program": "The Conquest of Mars: Is It a Reality?"; first paragraph is source introduction]

[Text] Mars. The planet of myths and science fiction, of the "war of the worlds" and "little green men." Mars—can it really be explored? Today the possibility is being seriously discussed by scientists and engineers, by cosmonauts and political leaders. It was even mentioned during the high-level Soviet-American meeting in Moscow in 1988.

From legend to reality

How quickly scientific information still becomes outmoded in our space age! It was not so very long ago that the imagination of earthlings was stirred by the astonishing possibilities of finding a world similar to ours several tens of millions of kilometers away—quite an insignificant distance in terms of the scale of the Universe. Remember how won over everyone was, for example, by the hypothesis involving the artificial "Martian canals" discovered by the Italian D. Sciaparelli: intelligent Martians had supposedly built those grandiose engineering structures for irrigation or as transportation arteries.

And the Martian satellites, which could be observed with only the very biggest telescopes? The American A. Hall, who discovered them, gave them the names of sons of the god of war: Phobos (Fright) and Deimos (Terror). A total of 25 years ago, the Soviet scientist I. S. Shklovskiy advanced the hypothesis of their artificial origin.

Serious scientific works also described the flora of Mars. "It must be, primarily, low vegetation that hugs the soil," conjectured USSR Academy of Sciences Corresponding Member G. A. Tikhov. "Mainly, it must be grasses and trailing undergrowth. In the severe climate, plants can be sky blue, blue, or even violet."

And here are the words of the American biologist F. Salsbury: "It can be assumed that the color and size changes of individual surface areas of Mars that we observe indicate the existence of luxurious vegetation on the planet...."

At the same time, opposite points of view existed. Academician V. G. Fesenkov felt that "no higher vegetation or developed animate world could be on Mars. But the existence on the planet of lower forms of certain lichens, primitive algae, or bacteria cannot be ruled out."

Alas, none of that, unfortunately, is so! Many facts from the "biography" of Mars are already known today. Their reliability is unquestionable—they were transmitted to Earth by Soviet and American spacecraft, regular launches of which to the "Red Planet" began in 1962. Earth's messengers carefully "examined" it close up, descended to its surface, and "told" such an astonishing story about Mars that the controversy about its secrets flared up with new force. Debunking certain hypotheses, they gave birth to a multitude of others.

New riddles

In the mid-1960s, it seemed that Mars was like the Moon more than anything else: a rarefied atmosphere (pressure at the surface of the planet matched that at an altitude of 30 kilometers above the Earth), a weak magnetic field, and the absence of radiation belts. The severe landscape, with its many craters, reinforced that similarity even more. Such a point of view was most widely held even after the flights of the first Soviet Mars craft and the American Mariners, although those vehicles did increase scientists' knowledge of Mars considerably. And then—new launches, new unique data about the planet, and the conclusion that Mars is not like the Moon. It bears no similarity at all. Mars is like...Mars.

It turned out that, in spite of Mars's modest size by Earth's standards (its diameter is smaller than the Earth's by almost a factor of two, and its mass is only 11% of the Earth's mass), its relief is much more rugged. Close-up surveys made it possible to differentiate surface features measuring a kilometer and, in favorable conditions, features measuring several dozens of meters (ZEMLYA I VSELENNAYA, 1974, No 5, p 7—*Ed.*). Not one "Martian canal"—over which scientific lances were broken for roughly a hundred years—was found. There are, however, many hundreds of branching valleys that are not unlike Earth's riverbeds. There are traces of what appear to have been the movement of glaciers. But there is no water!

Of course, with minus temperatures and the rarefied Martian atmosphere, water could not exist on Mars in liquid form. Apparently, though, there were periods in the planet's history that had a less severe climate. During those periods, there may have been not only rivers, but also lakes and even seas and oceans.

Many experts believe that rivers and reservoirs of water exist today in the subsurface layers of Mars, especially in the Hellas and Ellada regions. The latter is a depression more than fifteen-hundred kilometers wide and as much as four kilometers deep and with absolutely no craters. The cause of this may lie in the thick layer of sand and dust that covers its floor. Or could it be a frozen sea?

No conclusion has been reached about the total water content on Mars. There were disputes quite recently about what kind of ice the polar caps consist of—regular or dry (frozen carbon dioxide). A compromise, as it were, has now been reached: both exist. But the problem is far from solved. Some amount of water must have existed on the planet since as far back as when the planet was

formed, but volcanic activity (evidence of its existence in the past was apparent on the thousands of photographs taken from aboard the spacecraft) could have increased the initial amounts considerably. Without even allowing for volcanic activity, various estimates hold that the total amount of water on Mars must correspond to a layer as much as hundreds of meters thick and covering the entire surface of the planet. The study of the evolution of waters reserves on Mars is a key task.

When the unmanned craft made landings on Mars, they did not find any "traces" or vestiges of a material culture (ZEMLYA I VSELENNAYA, 1978, No 2, p 56—*Ed.*). It must be said that no one was even thinking about "brothers in intelligence" up to that time. But life? Fine, the most primitive! They did not manage to find microbes or even any kind of complex organic molecules. It is hard to believe that and even harder to admit it. The negative findings may be associated with, for example, the absence of the forms of microorganisms the program sought to detect, or with the choice of landing site, or with experimental procedures. Experience has shown in Antarctica, for example, that it is virtually impossible to detect biological activity with a single sample. But if you take a sample, keep it in a warm environment, and give the microbes a chance to grow into a dense colony, you can detect the biological activity.

But assume that there is no life on Mars today. It is probable that in the past, when rivers were flowing, there was a much greater chance for the existence of life. If an individual could travel one of the meandering river valleys and make a study of the geological strata along its banks, he would be able to learn much and make a comparison of the development of neighboring worlds.

If there was at one time an abundance of water on Mars, then just what did happen? How did that world become so cold and dried up? Why did almost no air remain in its atmosphere? And does something similar await our Earth?

Expedition to Mars: Fantasy, or reality?

A manned flight to Mars requires that specialists coordinate among each other and balance out three critical factors: the overall duration of the flight, the amount of time to be spent on Mars, and fuel reserves. In the traditional approach, which is aimed at minimizing fuel expenditures, the flight configuration includes a nine-month journey to the planet, a stay of more than a year and a half on the planet, and a return trip of 6-9 months. But although such a configuration is economical from the standpoint of fuel consumption, such a lengthy stay on Mars seems a bit frightening.

There are, however, faster routes. One, for example, involves the launch of two spacecraft 30 days apart. When the first of them approaches Mars, its crew descends to the surface of the planet in a small shuttle craft. Thirty days later, that craft takes off to meet the other, arriving spacecraft, which will at that point continue its motion, but now in the direction of the Earth. The advantage of such a configuration is that it does not require braking the heavy carrier-craft (the "parent" craft) and converting it to a near-Mars orbit and then again placing it into a flight trajectory to Earth. Such a configuration makes it possible to use considerably less fuel, it cuts flight time, and it conforms completely to the current level of technology.

There are yet other flight versions. Manned flight along an interplanetary trajectory would naturally also require the use of engines more efficient than liquid-fuel engines. Perhaps the most promising in this regard is a nuclear ion propulsion unit.

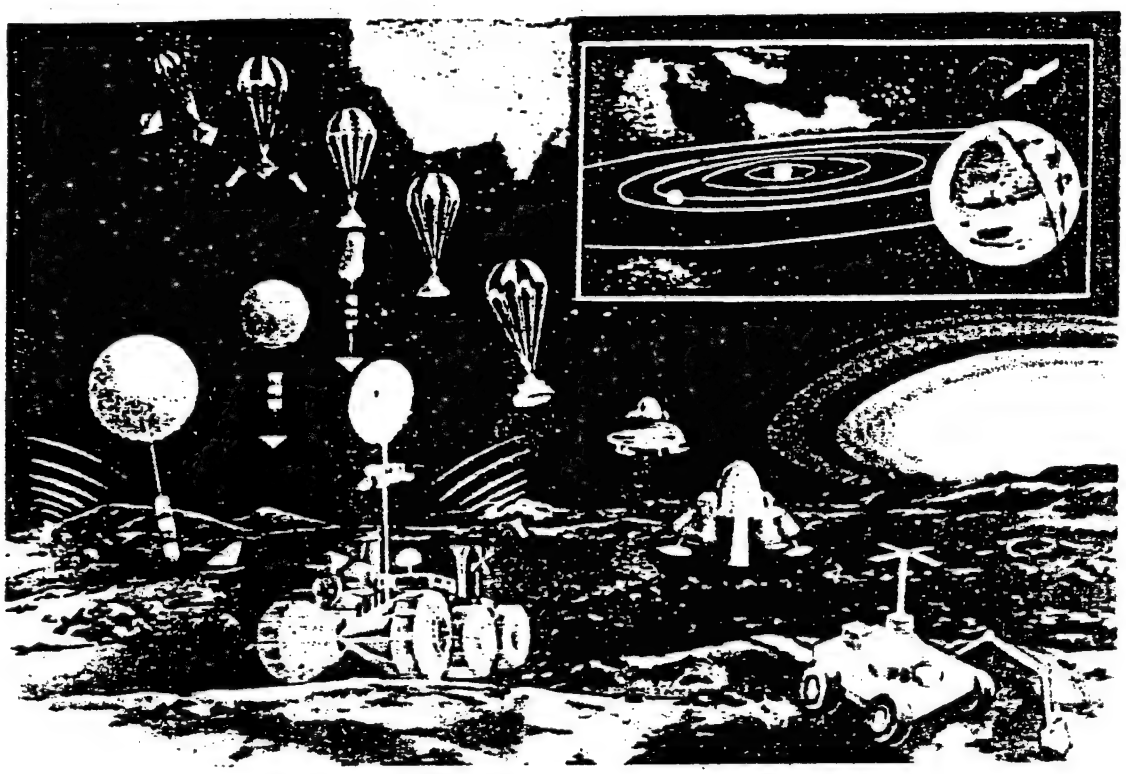
On the whole, it can be said that, at its current stage of development, manned flight to Mars is no more complex a task than flight to the Moon was in its own time, as compared with manned flight in near-Earth orbit (ZEMLYA I VSELENNAYA, 1973, No 5, p 30—*Ed.*). But the question here is different: is man himself capable of such a long stint in space—at least a year and a half?

As recently as 1987, the 326-day mark was reached for a man in space. That represents an argument in favors of man's being able to satisfactorily adapt to long-term exposure to weightlessness and, at the end of the flight, the Earth's gravity and to successfully return to a productive life on Earth.

In the future, artificial gravity—about which K. E. Tsiolkovskiy wrote as far back as the early part of the century—will quite probably be used in flight as a prophylactic measure.

Work is also being done to create autonomous ecological systems aboard spacecraft, which would be capable of a relatively long-term existence based on recirculation of matter, with their own mechanisms of self-regulation and self-control, as in Earth's biosphere.

Thus, we do not see any unresolvable problems. But since we are talking about man, his health, and his safety, every new step into space must be scrupulously weighed and must be based on the most painstaking, detailed study both of newly acquired data and all previous experience. Nothing must escape our field of view, including the long-term effects of space flight. Science—including space biology and medicine—must amass a still greater amount of facts about man and space, must understand the mechanisms of their complex interaction, and must help to achieve a harmony between the interactions. The manned expedition to Mars will become possible as a result of those efforts.



Some of the stages scientists imagine for the Mars program

What is the essence of the concept?

Man's flight to Mars will undoubtedly be a huge success for science. But one flight, even with man's participation, will not be enough to solve all the Martian riddles. The planet requires detailed studies that must be done from artificial-satellite orbit, on its surface, and in its interior. Man's presence is not necessary for these studies. It would be better to use "intelligent" robots. Launches of unmanned vehicles to the planet would make it possible to work out the flight technology and the research equipment step by step, to select the most interesting sites for subsequent landings, and to conduct the necessary investigations there. In a word, the automatic equipment must do an immense amount of work before man sets foot on the surface of Mars.

The launch dates for the unmanned vehicles will be determined by the power opportunities for placing large enough payloads into flight trajectories. Launches to Mars must take place when Mars is on the other side of the Sun, in "superior conjunction" with the Earth. Between now and the end of the current century, such "astronomical windows" for a launch to Mars will occur roughly every two years. Based on those time periods, Soviet scientists have developed a program for studying Mars in stages, the ultimate aim of which will be to bring soil samples back to Earth before the year 2000.*

The Phobos mission

Two Soviet space probes equipped with complex scientific instrument packages were launched to Mars on 7 and 12 July 1988 (ZEMLYA I VSELENNAYA, 1987, No 4, p 7—*Ed.*). At a point 9-10 months after that, they will pass at an altitude of only several dozen meters above the surface of Phobos. The beam of an on-board laser will repeatedly pierce its "earth." The vaporized matter, which will be unable to maintain the very weak pull of the "minimoon," will be thrown out into space. Trap devices aboard the spacecraft will catch it and perform a detailed analysis of it.

After that, two landing probes will descend to the surface of Phobos. One will be mobile. This small robot will hop about the surface, conducting the first geological investigations of the Martian satellite in history. The other probe, on the other hand, will affix itself securely on the surface with a special harpoon gun and will transmit valuable information back to Earth about the "life" of Phobos for about a year.

A broad research package is planned for Mars itself from aboard the spacecraft when it is moving in the orbit of an artificial satellite of the planet.

The research program devised by the scientists required the development of a new spacecraft of a class of "highly intelligent space robots." Our readers have already been

acquainted with the instrumentation of this craft, which was developed at the G. N. Babakin Experimental Science Center (ZEMLYA I VSELENNAYA, 1988, No 4, second page of cover—*Ed.*).

A combined program

The Phobos mission may be considered the first important step in carrying out the Mars program devised by Soviet scientists. The next stage is expected to take place in the 1990s. It calls for global research of the surface and the atmosphere of Mars with artificial satellites, balloon probes released into the atmosphere, surface excursion vehicles, weather probes and penetrator probes delivered to the surface, and a subsatellite that separates from the main craft. The research potential may be expanded considerably if aerodynamic braking of the spacecraft is used in the planet's atmosphere when the craft is going from a flight trajectory to its artificial satellite orbit.

One of the main tasks of the orbiter will be to make a superhigh-resolution survey of the surface of the planet. For this, specialists are proposing that, in addition to a stereo TV survey camera and a stereo TV high-resolution camera (with a resolution of about 20 m), the orbiter have a photographic camera with a resolution of 1 m and a film cassette that can be returned to Earth.

IR radiometer measurements will make it possible to do thermal mapping of the surface and to determine the thermal inertia of the soil, which will provide information on its structure and regolith particle size.

The scientific instrument package aboard the orbiter will also include a long-wave radar unit, a gamma spectrometer, a magnetometer, and a plasma assembly [plazmennyy kompleks]...

In one possible variation of the balloon probe research, the balloon will fly during the day only, descending to the planet's surface at night. For such operations, it will have to consist of two spheres that are linked to each other—a large one below with a plastic skin that is filled with Martian atmospheric air, and a small one above made of Mylar and filled with hydrogen or helium. The design parameters of the sphere below must be such that the sphere has lift during daylight hours only, when the Sun's rays heat the gas mixture that fills it. The use of this principle in the design of the balloon will make it possible to transport the scientific instrument package that is in a gondola a considerable distance from the landing site of the descent module.

The problem, however, is that, until the balloon acquires the necessary lift, the gondola will be dragged across the surface, which is probably very rough, for some amount of time. This could lead to snagging or breakage of the gondola and malfunctioning of the instrument package. Precluding such a possibility will obviously require a special gondola design and painstaking development of it on Earth in conditions similar to those on Mars.

One drawback of this method of balloon probe research is the random direction of transport of the balloon, which will depend entirely on wind direction. Nevertheless, existing data on the atmospheric dynamics of Mars make it possible to calculate the possible flight trajectories for the balloon and to choose those that are of greater interest. That, however, will require precise placement of the balloon in a given atmospheric region of the planet.

From an altitude of 200 meters, a TV survey camera aboard the balloon's gondola will provide resolution of 10 centimeters or better. The gondola is also planned to hold a meteorological package for measuring temperature, pressure, humidity, wind speed, and aerosol density.

One of the chief technical problems associated with the surface excursion vehicle involves controlling its movement from a distance of tens of millions of kilometers. The excursion vehicle must, for example, be able to go around obstacles that were not in its path 20-30 minutes earlier. It takes roughly that amount of time for radio signals to traverse the distance from Mars to Earth and back. The solution to the problem lies in making the vehicle an "expert system," by giving it certain "intellectual capacities." "Earth" will determine the strategy of operation, whereas the robot itself will determine the tactics for carrying that strategy out. If, for the orbiter, this implies autonomy in solving a number of navigational problems, then for the excursion vehicle, it means the most complex autonomous, adaptive (i.e., adaptive to conditions) control of motion.

In addition to a TV system, the excursion vehicle must be equipped with a laser range finder, which will provide image-depth "perception" and will make it easier to set a course and control movement.

The speed of the excursion vehicle will be determined by power-engineering considerations and will also depend on the terrain and research program along the path of movement. Thermal converters are considered to be the most preferable as a power source.

The creation of such "self-controlled" robots will serve not only science. It will yield no small amount of benefit on Earth. A prototype of the excursion vehicle, for example, was used in removing radioactive debris from the roof of the Chernobyl AES.

The research program proposed for the excursion vehicle is very broad. It includes seismic survey of the deep interior of the planet to obtain information about its internal structure, study of soil composition, and analysis of the soil's microstructure and its volatile components.

The excursion vehicle will also make it possible to obtain a series of panoramic photographs of the surface along the path of its movement. It will be able to collect rock samples from a large area and from a depth of several

meters (depending on the solidity of the soil). Collecting soil samples from deep layers is especially important from the standpoint of subsequent biological analysis, because it increases the probability of detecting some form of life.

The excursion vehicle will also have a meteorological instrument package.

It must be said that studying the weather conditions on Mars is one of the most important tasks of the first stage of the planned research of the planet. The creation of a network of small, long-lasting (more than a year) weather beacons on the surface of Mars is planned for this very purpose. Their primary task is to make direct measurements of meteorological parameters for the study of overall atmospheric circulation and for predicting weather conditions for the current mission and for future missions.

The advantages of such a system are global coverage; the possibility of placing stations in especially interesting areas (canyons and old riverbeds) that are inaccessible to study by other means; and all-season observation (thanks to their lengthy duration of operation), including observation during the season of dust storms.

After being released from orbit, the penetrators, by burying themselves in the Martian soil, should operate on Mars from one to four years. Several penetrators will form a network of stationary stations that provide long-term seismic observations, which will make it possible to obtain a large body of data on the internal structure of the planet.

The main task of the subsatellite will be to obtain data for constructing a high-spatial-resolution model of the gravity field of Mars. The studies will be carried out with precision trajectory measurements made by the orbiter-subsatellite system.

Earth-Mars-Earth

The delivery of Martian soil samples to Earth is the most complex element of the research program proposed by Soviet scientists. One version of the task consists of launching two independent vehicles: one of them lands on the surface of Mars, the other becomes a satellite of the planet. The vehicle that lands "touches down" at a predetermined site, where the excursion vehicle that was brought to the planet on the previous expedition is already awaiting it with the rock samples it has gathered (the excursion vehicle will also play the role of a radio beacon for the vehicle that is landing). The rock samples are then loaded with a manipulator onto the take-off rocket.

In addition, samples are gathered at the landing site by a small excursion vehicle carried aboard the lander. The small excursion vehicle is also equipped with a manipulator and a soil collection device that will enable samples to be taken from a rather great depth.

The take-off rocket will take the soil to the orbiting vehicle and will dock with it, after which the samples will be loaded onto the module that returns to Earth. Upon approaching our planet, the returning module can moor to an orbital station, where initial analysis of the Martian soil will be done. That will make it possible to resolve one of the most difficult problems of the expedition—effecting a quarantine that precludes contamination of our planet with extraterrestrial organisms that could be in the soil samples brought from Mars, however small the probability of such may be. Needless to say, the spacecraft must be sterilized before its launch from Earth, lest it carry terrestrial microbes to Mars.

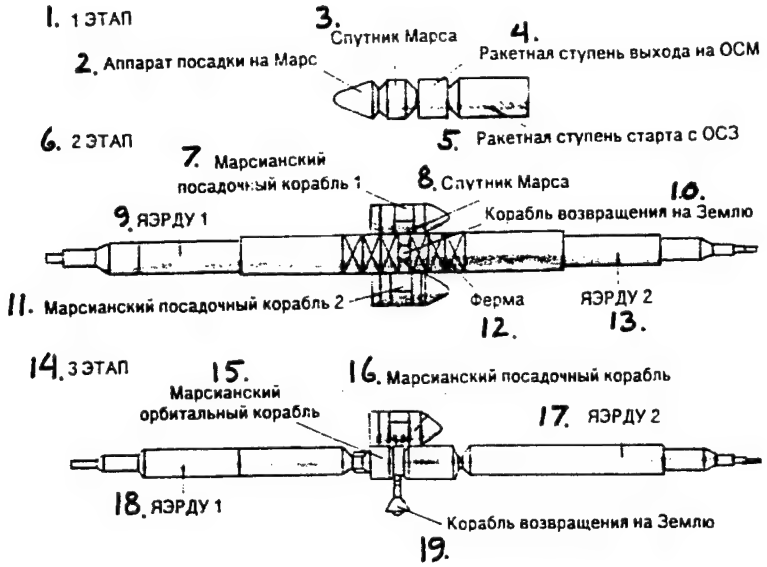
Bringing Martian soil back to Earth will make it possible to solve many riddles surrounding that planet. Analysis of the mineral composition, the noble-gas and volatile-substance content, and the elemental distribution of the samples will enable us to clarify the evolution of Mars. An isotope study will make it possible to date the rocks and obtain information about former geological conditions on the planet.

As for the hypothetical living Martian organisms, how they will hold up on the Mars-to-Earth trip remains an open question. After all, it could happen that, in a strange habitat, they might die before reaching Earth.

Of course, these Mars mission scenarios have not been finalized. Studies have shown that, in particular, combining the return of the photographic film with the performance of all the other tasks of the expedition will be difficult. Performing a detailed photographic survey of the planet's surface and returning the film to Earth may require the launch of a special vehicle. That would solve a number of specific problems associated with the use and transport of photographic materials—such as, for example, the problem of the alteration of the photographic characteristics of the photo layer when it is exposed to cosmic radiation.

At the same time, all these specific stages and bodies of research assume the use of the Proton launch vehicle to launch the spacecraft. The use of a booster like the Energiya, which is capable of delivering a much larger payload to Mars, creates fundamentally new possibilities for carrying out the Mars program. In the version that uses the Energiya, the future Mars program looks like this.

The first stage (1994-1996) consists of global studies of the surface and the atmosphere of Mars with a complex of heavy, unmanned vehicles. It calls for remote sensing studies of surface areas of interest from aboard a base station flying in an orbit that is almost a circular polar



Key: 1.Stage I—2. Mars lander—3. Martian satellite—4. Rocket stage for exit to Mars orbiting station—5. Rocket stage for start from Earth orbiting station—6. Stage II—7. Mars lander 1—8. Martian satellite—9. Nuclear ion propulsion unit 1—10. Craft for return to Earth—11. Mars lander 2—12. Framework—13. Nuclear ion propulsion unit 2—14. Stage III—15. Mars orbiter—16. Mars lander—17. Nuclear ion propulsion unit 2—18. Nuclear ion propulsion unit 1—19. Craft for return to Earth

orbit (at an altitude of 200-300 km). Mars will also be studied with direct methods on the surface with excursion vehicles, a drilling unit, penetrators, and small probes. In addition, its atmosphere will be studied with balloon probes, whereas electromagnetic and seismographic methods will be employed to uncover the secrets of the structure of the "Red Planet."

One of the main tasks of this stage is to find the most interesting site for the landing of a manned expedition and obtain data on the natural conditions of Mars, which will be taken into consideration when the equipment for performing a manned flight is being chosen.

The job of the second stage (2000-2005) consists of working out the basic elements of the manned expedition in the field. It calls for further studies of the Martian surface, plus a study of individual regions and delivery of Martian soil samples back to Earth. It will be a dress rehearsal for the manned expedition, but sans crew. For the first time ever, the interplanetary flight will be done with a nuclear ion propulsion unit.

And, finally, the third stage (2005-2010) is the manned expedition to Mars.

Together, or alone?

Scientific organizations and specialists from many other countries are expected to take part in the Mars research program proposed by Soviet scientists. The experience attending the Venus-Halley's Comet project showed just how effective such cooperation can be (ZEMLYA I VSELENNAYA, 1986, No 5, p 5—*Ed.*). The project was unprecedented in terms of the number of the participants from various countries who were directly involved in developing the equipment and instrumentation. It represented, one could say, the first step on the path to transforming space into an open international laboratory, something the Soviet program of "star peace"—a manifestation of a new way of thinking in the realm of space operations—is calling for. It is extremely important not only to preserve the spirit of scientific cooperation that emerged in the course of carrying out the Vega project and was further reinforced during the preparations for the Phobos project, but also to develop it further yet.

Man's flight to Mars, it would seem, is entirely impossible without international cooperation. Let us recall that the mission that put men on the Moon cost the United States $25 billion dollars. The cost of a manned Mars expedition, according to various estimates, will be between $50 billion and $250 billion. Such amounts are prohibitive for even the most highly developed country. The answer is obvious: the resources of different countries must be combined. And for such an expedition to make sense, its preparation—including preliminary flights of unmanned vehicles—must be carried out within the framework of a broad international program of long-term research. Then it will represent not merely a manned expedition to Mars, but the beginning of the conquest of the planet.

The planet that was given the name of the ancient god of war can become a symbol of nations coming together in the peaceful development and use of space.

**Ed. note:* ZEMLYA I VSELENNAYA will acquaint its readers with the individual stages of the Mars program as the program is defined more precisely.

Mars Mission Scenarios

18660111 Moscow ZNANIYE-SILA in Russian
No 12, Dec 88 pp 11-15

[Article by Ye. Nelepo: "Mission 'Mars': Idea—Experiment—Implementation"; first paragraph is source introduction to article]

[Text] A flight to Mars. Today this long-held dream of mankind is assuming completely realistic features. The possibility of a manned Mars expedition is being discussed seriously by scientists, cosmonauts, and politicians. During the Moscow meeting, M. S. Gorbachev suggested to R. Reagan that they set up a joint flight to Mars "not to compete to see who can pass whom in weapons, but to combine our potentials—scientific, economic, and intellectual—and to set an example of collaboration in this area."

Toward the cherished goal

According to the estimates of the experts, man's flight to Mars could take place between 2010 and 2015. But why not earlier? After all, some of the serious prerequisites for such an expedition have been attended to: the assembly of large complexes in space has been mastered, and powerful booster rockets have been developed (the Soviet Energiya is capable of putting around 100 tons of cargo into orbit). Many problems, however, remain unsolved for the time being. For example, we need to solve the problem of storing liquid oxygen and hydrogen—fuel for today's boosters. It's not fully clear how well man's body will be able to withstand a lengthy stint of weightlessness. Moreover, it's extremely important that we create a closed, or at least partially closed, life-support system. It's estimated that a crew of ten individuals will require no less than 70 tons of food products alone for the three-year journey in space. But it would hardly be sensible to take such a substantial reserve on the flight. The Martial spacecraft will already weigh several hundreds of tons, and the trip will lie before it won't be short—the shortest distance between the Earth and its "neighbor" in the solar system is 56 million kilometers.

A manned Mars expedition is a complex matter and requires the joint efforts of many countries. Just how effective the consolidation of scientific and production potentials could be in solving space-related problems was shown by the Venus-Halley's Comet mission, which was successfully performed on a broad international base.

"Mars represents a big objective in the study of space, and I think we should accept the challenge together," says Academician R. Z. Sagdeyev. "We have to be realistic. If the Americans are concerned that secret military technology will be given over to the Soviet Union, we must find a means of collaboration that does not require complete interaction at the stage of preparation and performance of the missions. For example, each side could send its own scientific gear to Mars, launched independently from Earth with its own country's rocket-and-space equipment, but operating within an agreed-upon program on Mars. I wouldn't exclude in the future the grandiose possibility of putting a jointly manned spacecraft into a Martian orbit or landing it on the surface."

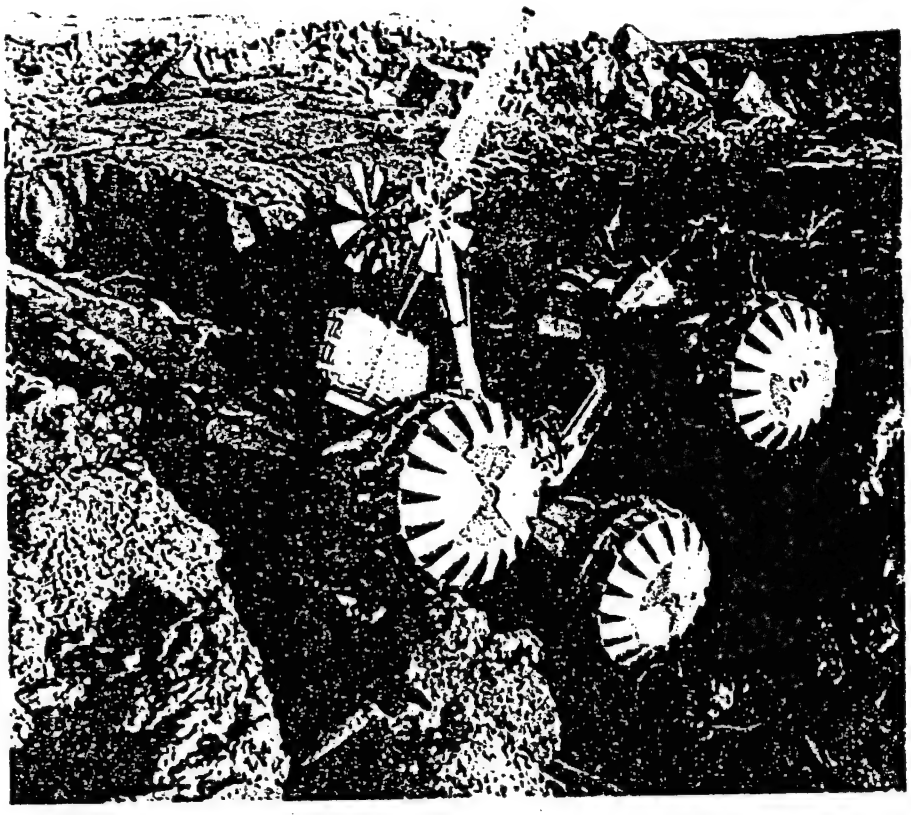
"The costs for the Martian research," he continues, "would be entirely acceptable. In any event, they are considerably lower than the annual expenditures of the two countries—the USSR and the United States—on nuclear weapons. The final stage—the manned expedition—would probably cost from 50 billion dollars to a 100 billion."

The attractiveness of a manned flight to Mars is, unquestionably, great. At present, however, the scientific yield from such an expedition would be rather low; after all, our knowledge of the Red Planet at the moment is rather "spotty." Most scientists feel that Mars should be studied first of all with unmanned vehicles that would enable us to perfect flight equipment, would help choose the most interesting regions for subsequent landings, and would conduct the necessary investigations there.

Unmanned craft blaze the trail

The Fobos mission, launched in July, opened a new chapter in our knowledge of the Earth's "neighbor." A new generation of devices developed by our designers is being tested on the expedition—so-called highly intelligent space robots, which will be the basic units for carrying out all of the rest of the Martian program. And just what will that program be?

An interesting scenario has been proposed by the scientists at the USSR Academy of Sciences Space Research Institute. It calls for performing a comprehensive study of Mars in the mid-1990s: a study of its surface, its internal structure, its atmosphere, and its magnetosphere and ionosphere. Each area includes a whole series of tasks. In the study of the planet's surface, for example, it will be necessary to analyze the elemental composition of the soil, to attempt to detect organic compounds in it, and to perform mineral mapping. Special attention must be devoted to permafrost zones. Once we know where they're located, we will be able to identify the warmer



One version of the future martian excursion vehicle

areas of the planet, which hold the most promise in the search for signs of life. A high-resolution photographic survey of the surface will provide accurate data on Martian relief, which are important for the proper selection of landing sites for future craft.

Carrying out such a grandiose plan requires a whole complex of state-of-the-art equipment. The traditional orbital craft is itself no longer enough, and scientists are proposing that balloon probes, martian excursion vehicles, penetrators (from the English, *to penetrate,* for the Russian *pronikat', vkhodit'*), weather beacons, a subsatellite, and return craft be "enlisted" to help it. The flight from Earth to Mars will take about 300 days. As a result of the aerodynamic braking in the Martian atmosphere, the spacecraft will go from a flyby trajectory to an elliptical orbit and then, later, to the circular orbit of a satellite. After identifying the landing regions, the lander will separate and weather beacons and penetrators will be released. A balloon will be released into the atmosphere, and the excursion vehicle will descend right to the surface of the planet.

Each element of the expedition has its own duties. The small subsatellite, for example, will enable scientists to produce an accurate model of the gravitational field of Mars, and the return vehicle will deliver to Earth film with images of roughly a third of the entire planet.

Balloon in the Martian sky

Balloon studies of the atmosphere of another planet have already been done: probes in the Vega expedition spend nearly two days in the dense, orange clouds of Venus, transmitting valuable scientific information back to Earth. The experience is there, but, in this case, it's not very suitable: the severe conditions of Mars, with its powerful dust storms, are markedly different from the "extremely warm embraces" of the Evening Star. For the cold, rarefied Martian atmosphere, the balloons need to be made from other materials and, perhaps, with a different design. An original balloon variation has been proposed by the French scientist Jacques Blamont. A so-called twin balloon consists of two spheres tethered to each other: a large one, with a diameter of about 10 meters, and a small one. The large plastic balloon, filled with air, is below, with the small one, filled with helium, soaring above.

During the day, the large balloon, heated by the sun, rises to a given altitude and flies in the atmosphere. At night, cooled off, the balloon descends to near the surface of the planet. It can never land on rocky, uneven soil, because the plastic skin could be damaged. So the "work" of the smaller balloon begins during the cold period of the day. It will hold up its large neighbor, suspended below, for

the whole night, and when the sun rises, everything starts all over. Over 10-15 days, the probe, blown by the wind, will cover nearly two-thousand kilometers.

A gondola with scientific gear is attached to the balloon. During the flight, miniature television cameras will make it possible to carefully scrutinize the Martian surface from the altitude of a bird in flight (from 200 meters, it will be able to distinguish things as small as 10 centimeters). A magnetometer investigates the deep structure of the soil, and a gamma/x-ray spectrometer studies its chemical composition. At night, all kinds of additional experiments are possible. Everything, it would seem, has been thought out in detail. However, tests conducted in the salt lakes region of the United States, where the landscape is reminds one of the Martian landscape, have uncovered new problems. Even a non-expert understands what they are when he sees a videotape of the tests. At night, the balloon continues to fly above the planet, and it is in no danger. The gondola that's attached to the balloon descends to the surface and bounces around on the hillocks and slams into crevices, all at great speeds (and strong winds are not a rarity on Mars). It turns out that a reliable means of protecting the contents of the gondola from impacts and vibrations has to be developed, or the very first Martian night will be fatal for the unique equipment.

On the surface

The project designers feel that, on the surface of Mars, it makes sense to use various kinds of long-term research equipment at the same time: both stationary and mobile.

They suggest releasing from planetary orbit several penetrators—landing probes—which will break through the surface layer of soil and, penetrating to a depth of 2-5 meters, will be firmly fixed at the surface. Scattered over a large area, they will form a stationary network for seismic and weather observations and for soil composition analysis.

We could deliver about a dozen small buoys (weighing just a few kilograms) to especially interesting, inaccessible areas of the planet, such as canyons and old riverbeds. Over the course of a year, the most minute weather information would go from these beacons to the Mars orbiter or directly to Earth receiving stations. The advantages of such a method of research are its simplicity, its reliability, and its ability to operate during all seasons, including the season of the dust storms.

Stationary research has been done on the surface of Mars before. Now, for the first time, a martian excursion vehicle will begin to move about the Red Planet. Over a two-three year period, it will cover up to 100 kilometers, making deep studies of the soil, collecting soil samples, and surveying the vicinity with its television camera eyes.

In design, the martian excursion vehicle is reminiscent of its older brothers, the lunokhods. Why, it's even being developed by the very same group that created those robots of worldwide renown. True, the principle of operation of the martian excursion vehicles will be completely different—the lunar vehicles were controlled from Earth. That was possible because a radio signal reaches the natural satellite of our planet in a little over a second. Mars is much farther from us than is the Moon, and a radio signal takes almost a half an hour to reach it. For that reason, there can't be any kind of control from Earth, no human intervention in the work of the martian automatic vehicles. The martian excursion vehicle will have to orient itself in the locale, set a course, make on-the-spot decisions, and overcome obstacles. It will be an expert system that has eyes—a special television camera—and artificial intelligence. The "terrestrial Martian" is expected to be equipped with a laser range finder that will enable it to "perceive" image depth. After it has carried out the entire mandatory program on Mars, the excursion vehicle will switch roles and become a radio beacon for the lander of the next mission.

The United States is developing its own program. It specifically calls for launching the Mars Observer satellite into a Martian orbit in 1992. The scientists hope to combine our efforts with those of the American mission. The benefit from such a collaboration would be mutual. Studies of especially interesting areas of the planet could be done, and the high-resolution television camera of the Mars Observer could be used to study places where the Soviet excursion vehicles are to be landed. The American satellite would be convenient as a relay station for transmitting scientific information from Soviet excursion vehicles and balloons. Back on Earth, it would make sense to set up a joint network for round-the-clock reception of data from all the artificial Martian satellites, create a combined data bank, and arrange the exchange and joint processing of the most valuable information.

A dress rehearsal?

If the studies are successful, the soil samples taken by excursion vehicle could be delivered to Earth in the early part of this coming century. Loaded with the samples, a return rocket would achieve a Mars orbit and dock with an awaiting spacecraft ready to return to Earth.

Two variations for the return are being examined: direct flight from Mars orbit to Earth, and a journey with an intermediate "stop" in near-Earth orbit. The second variation is, of course, more complex, technically speaking, but it entails preliminary analysis of the Martian soil on an orbital station. The quarantine problem is thus solved, eliminating the possibility of contaminating our planet with extraterrestrial organisms. Of course, the spacecraft will have to be sterilized before it leaves Earth, so it won't carry Earth microbes to Mars.

The delivery of Martial soil will constitute a dress rehearsal of a piloted Earth-to-Mars-to-Earth flight. But maybe not. Ideas involving combining delivery of the soil with manned flight to Mars are being broached. Such suggestions make sense. In fact, automated performance of the entire of string of operations involving the relay of the samples from the excursion vehicle to a rocket, and then from the rocket to a spacecraft returning to Earth, is extremely complex. It would be another matter altogether if the automatic equipment could be backed up. How? A cosmonaut in an orbiter could control the robots, quickly intervening in their actions. The robots, with "man's eyes" and "high-speed hands," would perform all the tasks that a human working right on the distant planet would have to perform. This orbital variation of the expedition by no means excludes the possibility of a cosmonaut "strolling" a while on the planet and then returning to the orbital station to continue the research.

Such is how the first Mars mission may go.

UDC 523.4

Distribution of Domes on Venusian Surface According to 'Venera-15'-'Venera-16' Data
18660107a Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22 No 4, Oct-Dec 88 (manuscript received 1 Feb 88) pp 287-297

[Article by Ye. N. Slyuta, O. V. Nikolayeva and M. A. Kreslavskiy, Institute of Geochemistry and Analytical Chemistry im. V. I. Vernadskiy]

[Abstract] Domes with diameters from 1 to 20 km occur widely on radar images of Venus. A geological-geomorphological analysis suggests strongly that these features are of a volcanic nature. The distribution of domes in the survey area is quite nonuniform. Most of the domes occur in clusters. The principal dome clusters are described. Some of these clusters can be regarded as independent structural-tectonic formations because they are well expressed in both the relief and in the gravity field of the planet. Much like similar formations on the Earth, the domes on Venus were evidently formed primarily as a result of effusive activity. The dependence of the density of distribution of domes in the survey zone on relief elevation, which suggests that regional geological processes control the distribution of the domes about the surface, is examined. The greatest density of domes is associated with the zone tectonically most active in the past, making it possible to postulate that the distribution of domes is controlled by planetary-scale orogeny. Most of the domes are volcanic structures of the central type. The dome clusters are some of the most recent, although probably not the latest Venusian landforms. Figures 8; references 9: 7 Russian, 2 Western.

UDC 523.4

Scientific Plans of 'Magellan' Expedition
18660107b Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22 No 4, Oct-Dec 88 (manuscript received 16 Mar 88) pp 298-306

[Article by R. S. Saunders, Jet Propulsion Laboratory, California Institute of Technology]

[Abstract] The next NASA interplanetary flight will be the "Magellan" expedition for mapping of the Venusian surface (the materials presented in the article represent the results of work done at the Jet Propulsion Laboratory under NASA contract). The "Magellan" spacecraft will be the first interplanetary ship put into orbit by means of the shuttle system. The launching period will extend from 29 April to 23 May 1989 and entry into an orbit around Venus will occur about 10 August 1990. The vehicle will operate in orbit for 243 days following a 15-day period of orbital correction. It is expected that by using a radar with a synthesized aperture it will be possible to map at least 70% of the Venusian surface with a resolution of 240 m or less. The spacecraft altimeter will make it possible to obtain vertical profiles of the surface and measurements of the Doppler effect will make it possible to obtain information on the planetary gravity field. The article is accompanied by a time schedule of the expedition, a diagram of the surface area to be mapped, a sketch of the "Magellan" radar system and a table listing the technical specifications of the radar. Figures 4; references: 3 Western.

UDC 523.4

Scientific Objectives of 'Mars Observer' Expedition
18660107c Moscow ASTRONOMICHESKIY VESTNIK in Russian Vol 22 No 4, Oct-Dec 88 (manuscript received 15 Mar 88) pp 307-318

[Article by A. L. Albee, Department of Geological and Planetological Sciences, California Institute of Technology]

[Abstract] The "Mars Observer" expedition is to begin in September 1992 with the placement of a space vehicle with remote sensing capabilities in an orbit around Mars. The preliminary work described in this article was done at the Jet Propulsion Laboratory under NASA contract. The objectives will include determination of the global elemental and mineral character of surface material; global topography and gravity field; nature of magnetic field; temporal and spatial distribution, quantity, sources and damps of volatile components in the course of a seasonal cycle; research on structure and character of atmospheric circulation. The first three tasks will include quantitative geological, geochemical and geophysical measurements and an attempt to understand the distribution of chemical elements and minerals and nature of deposits and weathering of surface rocks.

The surface to be mapped has an area of 144 x 10^6km^2, which will be observed during the entire Martian year (687 Earth days). The article describes the instrumentation to be used and includes a time table of the observations. Figures 5; references: 3 Western.

UDC 523.43-87

Refinement of Orbits of Phobos and Deimos Using Surface and Space Observations

18660116 Moscow PISMA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 14 No 12, Dec 88 (manuscript received 24 Aug 88) pp 1123-1130

[Article by V. A. Shor, Theoretical Astronomy Institute, USSR Academy of Sciences, Leningrad]

[Abstract] The Sinclair analytical theory was used in processing surface observations of the Martian satellites for the period 1877-1986, supplemented by satellite observations from Mariner 9, Viking 1 and Viking 2. The orbital elements of satellites found from surface and space observations are compared. The secular acceleration of Phobos was determined with a high reliability. Estimates of the accuracy of the precomputed areoequatorial coordinates of these satellites for 1989 are given; tables give the complete orbital elements of these two satellites as determined from both surface and satellite determinations and their coordinates and velocities for February 1989. A further refinement of the accuracy of the theory can be expected if sufficiently complete series of observations are obtained during the impending opposition of Mars with internal accuracies of about 0."1-0."3. Figure 1; references 12: 5 Russian, 7 Western.

UDC 523.72:523.43

Numerical Simulation of Influence of Neutral Martian Atmosphere on Interaction with Solar Wind

18660134 Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 27 Jul 87) pp 934-942

[Article by T. K. Breus, A. M. Krymskiy and V. Ya. Mitnitskiy]

[Abstract] Numerical computations of bow shock front position near Mars were made for a situation when the boundary of the obstacle decelerating the solar wind passes at an altitude of 300 km from the surface, whereas in the transition region there is a loading of the solar wind due to the photoionization of the neutral Martian atmosphere and a charge exchange between solar wind protons and neutral hydrogen. It is shown that loading of the solar wind due to photoionization will displace the front away from the planet, whereas charge exchange will position the front in the subsolar region (however, the contribution of the latter process is small in comparison with the contribution of photoionization of heavy ions). These phenomena will be observed under definite conditions when the still quite dense atmosphere is not protected against the solar wind by the planet's intrinsic field. Such a situation possibly occurs either with high dynamic pressures of the solar wind or in the region of the daytime cusp, particularly if the magnetic dipole of Mars has a small inclination to the ecliptic plane. It is also possible, as in the Earth's magnetosphere, that a "bald spot" is formed in the subsolar region, a region in which the magnetosphere is eroded and accessible for the penetration of the solar wind to low altitudes in the atmosphere. All these assumptions and estimates and the results of computations require checking. Figures 3; references 25: 3 Russian, 22 Western.

Specialists Discuss First Imagery Received From 'Phobos-2'

18660148 Moscow IZVESTIYA in Russian 22 Feb 89 p 1

[Article by S. Leskov]

[Excerpt] "When specialists saw Mars' satellite on the screens of display devices, they probably felt as Columbus did when he finally spotted land after his long voyage," said K. Sukhanov, deputy director of the flight of the spacecraft "Phobos". "Note the high quality of pictures which were taken from a distant orbit of 800-1,000 kilometers. This means that the spacecraft's equipment is in perfect order after a flight lasting many months."

The world's largest antenna that is completely rotatable, the RT-70, is receiving incoming information from "Phobos".

A day before the first pictures of Phobos were received, calculated ballistic data from the Flight Control Center (TsUP) on the positions of the Martian satellite and the Earth with respect to one another were fed into the spacecraft's onboard control complex and computer, and the most optimal routine for picture-taking was selected. All operations on the day the pictures were taken had been rehearsed at the Research and Testing Center imeni Babakin, using simulating equipment. Turning precisely in the prescribed directions, the spacecraft carried out three sessions of television picture-taking with different cameras on Tuesday. Nine pictures in all were obtained, fixed with a recording device, and then transmitted to the Space Telecommunications Center in Yevpatoriya and from there to TsUP in suburban Moscow.

The importance of the pictures for the further course of the expedition cannot be overestimated. According to Professor N. Ivanov, head of the ballistic service, the pictures will allow navigational problems to be solved in the course of the upcoming approach to Mars' satellite. It is important to note in this connection that Phobos was right in the center of the picture in all nine frames, which attests to the precision of calculations made on Earth.

Are the pictures that were obtained of scientific significance? Professor G. Avanesov thought that it was still too early to talk about direct contributions to planetology. American "Viking" stations actually photographed Phobos from the substantially closer range of 80 kilometers. For us, this stage is still to come. "After all, the 'Phobos' research program includes celestial-mechanics experiments which consist in ascertaining orbit parameters of Mars and its satellites more precisely," added Professor V. Pochukayev. "The positions of the spacecraft and the satellite with respect to one another have now been determined with a precision of 10-15 kilometers. In the future, a measuring precision on the order of a single kilometer must be achieved, and from a distance of 200 million kilometers.

FTD/SNAP

'Termoskan' IR Instrument on 'Phobos-2' Performs Thermal Mapping of Mars

18660149 Moscow IZVESTIYA in Russian
25 Feb 89 p 1

[Article by A. Selivanov, Doctor of Technical Sciences, head of a department of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research (Glavkosmos) and M. Narayeva, Candidate of Technical Sciences, senior expert of USSR Glavkosmos]

[Excerpt] Execution of the "Phobos" project is approaching a highly important stage: landing of unmanned spacecraft on Mars' natural satellite.

A completely new experiment is in progress—preparation of a highly detailed thermal map of Mars which makes it possible to distinguish between the temperatures of individual formations on the planet's surface: craters, valleys, fissures, etc. This work is performed by an instrument called "Termoskan". Its nearest (and less highly perfected) terrestrial counterpart is the infrared imager, which is sensitive to heat (infrared) rays.

The original plan of work calls for the Termoskan to begin operating in the month of April in a circular orbit with an altitude of 6,000 kilometers. Under these conditions, details as small as about 2 kilometers are distinguished on the planet's surface, and an area 600-700 kilometers wide is scanned. But before shifting into this orbit, the "Phobos" station will have made several revolutions around Mars in an intermediate elliptical orbit with a minimum altitude of about 800 kilometers. The project's participants naturally wished to conduct surveying from a distance substantially smaller than the rated one, which proportionally increases resolution of small details on the planet's surface; details as small as a few hundred meters can be distinguished. Such unique scanning was carried out successfully on February 11.

Several large craters came into the Termoskan's field of view at the end of the session. One crater which was photographed is about 30 kilometers in diameter and is as yet unnamed. The photograph itself is the result of preliminary processing of an infrared image which was conducted at the Scientific Research Institute of Space-Instrument Building of the USSR Main Administration for Development and Use of Space Technology for the Economy and Scientific Research and at the USSR Academy of Sciences' Institute of Problems of Information Transmission. It must be noted in particular that the values of temperatures on the planet's surface which are given at various points on the image are strictly preliminary ones; they will be determined more precisely in the course of further processing. Pictures taken in the visible frequency range were an important supplement to the pictures obtained in infrared beams that are invisible to the eye. Pictures in the visible range are obtained simultaneously with the infrared ones in the Termoskan and are used for comparative analysis.

FTD/SNAP

Imagery Obtained From 'Phobos-2'

18660150 Moscow PRAVDA in Russian
2 Mar 89 pp 1, 6

[Article by A. Tarasov, special correspondent at the Flight Control Center]

[Excerpt] The "Phobos" control room is filled to the limit with video monitors and personal computers. The period of transmission of the second series of pictures of Phobos from the space telecommunications station in Yevpatoriya was beginning here.

There were 15 pictures, and they have been taken by the video complex "Fregat" from a distance of approximately 300 kilometers—the minimum for this orbit.

K. Sukhanov, deputy director of the Research and Testing Center imeni Babakin, who is simultaneously a deputy flight director, was asked: "What did today's picture-taking add to that which was done previously?"

"It also is navigational in character. But now that Phobos' shape has been studied more closely, ballistics specialists will be able to find the satellite's center of mass in inertial space and hence to calculate more precisely the orbits of Phobos and the spacecraft and their positions with respect to one another. A few days will be spent ascertaining more precisely parameters of their movement with respect to one another, after which one more active rendezvousing maneuver will be executed in approximately a week."

A day earlier, the "Fregat" took pictures of Mars and Jupiter for the purpose of aligning the axes of the video complex and the station, Konstantin Georgiyevich added. These pictures made it possible to transmit from the Ussuriysk antenna, on the morning that pictures of

Phobos were taken, corrections of commands of the day before which were in the station's onboard control complex. Exposure times were corrected, in particular.

What was the duration of these exposures, incidentally? It turns out to be not minutes or seconds but milliseconds!

In the "Phobos" room, I ran into Viktor Blagov, deputy director of the space mission 'next door'—the near-Earth one.

"What are you doing here?"

"Oh, we're conducting a training exercise for manner missions to Mars...What a crew will see while approaching Mars and Phobos."

FTD/SNAP

'Phobos-2' Said To Provide Evidence of Mars Magnetic Field

18660151 Riga SOVETSKAYA LATVIYA in Russian 3 Mar 89 p 1

[Article by O. Borisov, science commentator]

[Excerpt] Results of the initial stage of research of the planet Mars have been summarized at a joint meeting of Soviet researchers and foreign colleagues of theirs who have been taking part in carrying out the space program "Phobos". This meeting was held at the USSR Academy of Sciences' Institute of Space Research (IKI).

After becoming a satellite of Mars, the interplanetary station operated for two weeks in the first of four planned orbits. In the process of initial revolution in a very elongated ellipse, the station's nearest approach to the planet's surface was 800 kilometers. What new things were found out about the nature of Mars during this stage?

A succession of earlier American and Soviet spacecraft were never able to find out if the planet has a magnetic field of its own. Did "Phobos-2" finally perceive such an invisible field?

As is known, Mars is surrounded by a plasma mantle, and it is always possible for electric currents to circulate in such a conducting medium (as they do above the Earth). These currents generate a magnetic field.

Indirect evidence of a primordially generated field nevertheless exists, declared A. Galeyev, corresponding member of the USSR Academy of Sciences and director of IKI. When the spacecraft was in deep shadow, i.e., on the dark side of the planet, signs of the existence of radiation belts near Mars were discovered. We know from our own planet's experience that its magnetic field serves as a trap for high-energy charged particles.

The high-speed solar wind acts continuously on Mars' own plasma coat. A friction effect is constantly present at their interaction boundary, with the result that Martian plasma is carried off little by little into interplanetary space by solar plasma. Does this mean that it can 'abduct' atmospheric particles, too?

The fact is that plasma rushing out from the sun consists mainly of hydrogen ions. Mars' atmosphere contains various chemical elements, including ones in the form of ions. Instrumentation of "Phobos-2" makes it possible to distinguish these components. And when ionized oxygen that is obviously of Martian origin was recorded at a distance from the planet, it became clear that there are solid grounds for a hypothetical mechanism whereby Mars' gaseous envelope 'blows away'.

Studies of the planet's surface in the infrared range have made it possible to discover minerals containing water in the crystalline state. Further probing from the station will indicate the extent to which water-containing minerals occur in soils of Mars.

FTD/SNAP

Experts Discuss Psychological Support Measures for Cosmonauts

18660131 Moscow LITERATURNAYA GAZETA in Russian 4 Jan 89 p 10

[Interview by LITERATURNAYA GAZETA correspondents with Deputy Flight Director V. D. Blagov, division chief of the Center for Cosmonaut Training R. B. Bogdashevskiy, division head from the USSR Ministry of Health Institute of Biomedical Problems V. I. Myashnikov, psychological support group director at the Flight Control Center O. P. Kozerenko, chief of the Division for Cosmonaut Training at the Scientific Production Association Energiya S. V. Bronnikov, and research associate in the Cosmonaut Training Section at Energiya V. B. Alekseyev, under the rubric "The Science Scene": "Try to Spend a Year in Space..."]

[Text] *V. D. Blagov, deputy flight director, R. B. Bogdashevskiy, division chief at the Center for Cosmonaut Training, V. I. Myasnikov, division head at the Institute of Biomedical Problems, USSR Ministry of Health, O. P. Kozerenko, psychological support group director at the Flight Control Center, S. V. Bronnikov, chief of the Division for Cosmonaut Training at the Energiya Scientific Production Association, and V. B. Alekseyev, research associate in that division discussed how psychological support of cosmonauts is implemented during long-term missions on an orbital station.*

1. The People We Choose

Bogdashevskiy: Before we can discuss psychological support of crews, there has to be someone to support. Concern about the medical and psychological welfare of cosmonauts starts long before a flight—it starts at the screening and training stage.

[Question] **What percentage of candidates makes it through your screening?**

Bogdashevskiy: About 25 percent. I am referring to the final stages. However, at the stages of primary screening the percentage is minimal. We dig through hundreds of people, but select only a few. The ratio is about 1 out of 100. It is based on medical, psychological and occupational criteria.

[Question] **But the people who apply do not just come in off the street. The people who come to you have already been screened. For example, pilots. You screen people who have already been screened before. Is it worthwhile?**

Bogdashevskiy: Yes, it is. Our task is to reduce to a minimum any human-related contingencies. Suppose that an individual becomes sick during a spaceflight. That's it. The end. The flight is actually aborted. And this is too expensive a luxury for the Soviet people.

[Question] **Do candidates undergo intelligence tests? What kind?**

Blagov: The usual. The so-called Wechsler tests. They are well-known to any psychologist. In addition, they have to pass a special exam in space engineering. This actually also tests intelligence. Many engineers who come before the commission do not pass this test. Some have passed the physical, for example, but have failed this examination three times.

[Question] **But no matter how you screen or train people, there can still be problems. Both psychological and medical. Could you cite an example of such a problem?**

Bogdashevskiy: One example is what happened to cosmonaut V. Vasyutin, who developed an acute illness during a flight. All attempts to treat it in orbit failed.

Myasnikov: In space, an illness acquires a somewhat different coloration than on earth: along with the suffering due to pain and malaise, there is psychological stress. In other words, other conditions being equal, a cosmonaut suffers more than any other sick person. The possibilities for treating him are limited.

[Question] **Are psychologists listened to when crew assignments are made?**

Blagov: Of course they are listened to, as are other specialists. But after all, there are also other opinions. They are no less important. For example, how could one fail to consider the opinion of the president of France who named Chretien as a candidate?

Myasnikov: Technical management still has the final word on crew selection, rather than medical men or psychologists. And that is certainly appropriate.

[Question] **Can one pull strings to today to fly on a mission?**

Myasnikov: I don't think so, at this point.

[Question] **Have there been cases in which a crew readied for a mission was re-staffed at the recommendation of psychologists?**

Bogdashevskiy: Yes. For example, the L. Vorobyev and V. Yazdovskiy crew. It was dissolved for psychological reasons. Another crew went in their place, P. Klimuk and V. Lebedev. Because by then there had already been cases in which tension that arose between cosmonauts during a flight hindered the performance of their tasks.

Myasnikov At present, technical management has virtually no choice. Two crews are not enough. There must be at least three trained crews. Then it is possible to a greater extent to take psychological factors into consideration. But at the present time, we have to put up with the psychological flaws, since there are no other people trained in solving technical problems. The technical side of things, of course, gets preference.

Blagov The case of the L. Vorobyev—V. Yazdovskiy crew is, of course, an exception rather than the rule. It was a situation that was, as they say, hopeless. At one time, I was in rather close contract with Yazdovskiy—we sailed for several months on the same ship, also, one could say, in close quarters, and I understand the decision made by the people who decided to ground him. In general, I cannot comprehend how he became a crewmember.

Bogdashevskiy: It was very simple. He was a rather prominent figure at one point. He formulated the scientific program for that mission. He was rather good in taking on such roles. But then he had to shift to the role of operator-cosmonaut. Psychologically, he was unable to make the transition. Having become a cosmonaut, he continued to speak with the entire system from the standpoint of a program director. Naturally, the system rejected him. Especially since he also was found to have internal character traits that were contraindicated for the role of cosmonaut.

Myasnikov I believe that the technical management should make the decision about the appointement of the crew commander, and then the commander should be granted the right to pick his partner. Then the psychological condition of the crew would be more solid. Although there would not be a 100 percent guarantee against certain contingencies here, either.

Blagov This makes good sense. After all, when we go on leave, on some trip, we also try to pick a partner for ourselves.

2. What Is Psychological Support?

[Question] **Say a crew now has been selected and trained, and it is on a mission. What does psychological support consist of?**

Kozerenko: All our work is directed toward seeing that crew members are constantly engaged in their work. For this, they must be constantly included in current life, they must not feel that they are severed from the overall system of living. If we vascillated before about telling them of any problems in their families, at the present time we have no doubt about it: they must be informed of everything. Information is relayed to them via the radio communication and telecommunication channels. Conversations are scheduled that help compensate for the lack of direct social contacts. These are communications that concern problems that have nothing to do with work—communications with their families, fellow workers, friends, cultural figures, political observers and sports commentators.... It was during this mission that both the winter and summer olympics were held. We transmitted broadcasts of many of the competitions up to them. Members of the Shparo expedition and participants of the Moscow-Lisbon motor run were invited to talk with them....

[Question] **Are there any mandatory daily transmissions to the Mir orbital station?**

Blagov: Yes, excerpts from the "120 Minutes" program, the entire "Vremya" program, and a survey of the news in the newspapers.

Bogdashevskiy : The survey of the news is transmitted in the mornings, whereas they usually get news from home in the evenings. And news from our village, Zvezdnyy Gorodok.

[Question] **If the living conditions at the sanatorium where V. Titov and M. Manarov are now staying are taken to be 100 percent, how would you assess the comfort of cosmonauts aboard the station?**

Blagov: That is not an appropriate question. Let us put it differently. Of course, the cosmonauts' life on the station is more difficult than in the ordinary apartment of an average Soviet citizen.

Bogdashevskiy: Therein lies the substance of psychological support! We actually try to pattern their conditions after the normal life in a communal apartment.

Blagov: Of course, they get excellent food. Everything is brought in right on small plates in cargo spacecraft. Even fresh vegetables and fruit. The cosmonaut's diet consists of absolutely ideal food, from the standpoint, of course, ground-based standards; everything is nutritionally balanced. But that is where it ends: you have the close quarters, and the weightlessness that has a constant depressing effect not only on physical condition, but also on mental condition. A person cannot help but start to "get wound up."

[Question] **Tsiolkovskiy's idea that weightlessness is beneficial is not proving to be correct?**

Blagov: Not as yet. I believe that weightlessness is an enemy that one has to fight every day. Otherwise one could be the loser.

[Question] **Does weightlessness have an adverse effect on everybody?**

Blagov: Each individual is affected differently. There are some who are resistant, and there are some who experience discomfort throughout a mission. According to the cosmonauts, headaches persisted for virtually the entire period of the mission. Only the severity changed. At first they were very severe, since the body had not yet adapted, and later they grew milder.

[Question] **What causes the headaches?**

Blagov: Dilatation of cerebral vessels. The brain issues commands to other organs—adjust the pressure, relieve tension—and it affects the autonomic system through

pain. Man, of course, becomes accustomed to such pain, but it has not been possible to eliminate entirely the extremely unpleasant sensations.

[Question] **Are such states simulated on the ground?**

Blagov: Of course. Let me cite my own case. For about two of the four months I sailed on a research ship, I was tormented by similar pains. It was autumn, and there were constant storms. The endless, rough seas elicit a similar sensation. You feel yourself beginning to grow numb. You do not feel like eating, or drinking, or reading, or working. I felt that I was disappearing somewhere, that some physical substance was left that was constantly aching, and my personality was absent. But if you take hold of yourself and start to exercise, things get better. In space it is even more difficult. For this reason, the medals that had been criticized should have been awarded fairly, in my opinion. This must be recognized. Not to mention the risk taken.

[Question] **What is the least favorite thing cosmonauts have to do during a mission?**

Myasnikov: They do not like to exercise or do monotonous, routine work. The same as everyone else.

[Question] **And what is their favorite thing?**

Myasnikov: In my opinion, visual observation. It is very beautiful.

Blagov: All cosmonauts love freedom most of all. Freedom of action. For them to have at least a bit of time to do what they wish.

[Question] **Do the Americans have the same psychological support system, or a different one?**

Myasnikov: They have none. For a long time, they ignored psychology entirely. It was because they did not have long-term missions and because, in general, that is their life-style. They believed that everything was properly taken care of by money, by the amount for which the cosmonaut signs a contract with NASA. Now, they realize that that was an oversight, and they are trying to correct it. They plan to organize a psychological service. Beginning in 1992, when they will start operating a long-term station in orbit, they will of course encounter the same problems that we are encountering.

Blagov: We who work at the Flight Control Center are, in a sense, consumers of the "product" that the Cosmonaut Training Center delivers. We get different crews—crews that are mentally stable and crews that are not very stable. All these people are in very good health physically, with some bent for operator work, but psychologically they are very different. And in terms of compatibility, of course, they are not assigned to crews in an ideal way. All this must be taken into consideration. We try to find a particular line of behavior with each crew. In my opinion, herein lies the substance of psychological support. How do you withstand a year-long mission when the crew is in a confined space, when daily you have to look at a face that, perhaps, you have already grown tired of and you have to converse with that person? The main thing is for there to be motivation to perform your job. Of course, there are breakdowns, and this too requires psychological support. But the main thing is that there must be strong inner motivation. If there is none, you cannot achieve anything with any sort of psychological measures.

[Question] **You said that each crew has its own psychological picture. What was typical for the V. Titov—M. Manarov crew?**

Blagov: For every crew, interaction between the crew and the ground grows more complicated in the second half of the mission. The onset of complications occurred later for that crew than for others. That is, the cosmonauts demonstrated greater reliability.

Bronnikov: During that mission, they "produced"—more so than any of the previous cosmonauts—an enormous number of suggestions on improvement of the design of the station. We recorded 1,200 suggestions aimed at refining the most varied of systems. Of course, many of the suggestions overlapped and some were repetitious (after all, an entire year had elapsed). But even if 300 remain after processing, it points to a flair for innovation in both cosmonauts.

Blagov: I believe that the main objective for A. Titov was to get to the station. After all, this was his fourth attempt. This was a matter of self-affirmation. If something had had happened the fourth time, I do not know what would have happened to him....

Myasnikov: As the psychiatrists say, he could have gone into a profound neurosis.

[Question] **To what sort of unsuccessful attempts are you referring?**

Blagov: ... Once he could not effect docking. The second time, there was a prelaunch accident. The third time, a back-up crew was picked on medical grounds. So when he finally reached the station, his motivation to fulfill his assignment was, of course, very strong.

[Question] **Who is closest to the cosmonauts during a mission?**

Myasnikov: There are a total of five people, if we do not count the enormous number of other specialists who are in contact with the crew in some way or other: a briefing officer, a physician and three communications operators, which we call the Zarya operators (call name for the ground). Vladimir Alekseyev, who is here, worked in that role for 15 years.

Alekseyev: Operators also have to participate in psychological support. After all, it is primarily their voices that cosmonauts hear day after day. Our shift lasts 24 hours. We sleep near the console at night, in case we are called. There are some funny incidents. Once, at 2 a.m., during the mission of the A. Gubarev—G. Grechko crew, I hear a call. Everybody got excited. It turns out that a unit to heat water had been installed on the station for the first time, and the boys had had some hot tea. This made them so happy that they decided to share their joy with us.

Kozerenko: On the eve of 1 April, my doorbell rang at home. The duty officer at the Flight Control Center said: "The crew needs some humor." I had to go there.

[Question] **What are your guidelines in working with the crew?**

Alekseyev: For many years we have lived together, worked together, celebrated all the holidays together, and traveled together. So that everything is based on mutual trust. We understand each other before a word is half-uttered. I can converse with the crew in our own "pigeon" language, no one else would understand it, but it is all clear to us.

Myasnikov: Volodya [Alekseyev], if you sense that there are tense relations between the cosmonauts, what do you do?

Alekseyev: This happens often. For example, there was a problem with Yu. Romanenko. He would begin, first thing in the morning, "putting down" the ground services. I had to use humor. In a short time his tone would change.

Blagov: Unfortunately, not all operators are so capable. The relationship with cosmonauts in orbit has to be balanced: you have to avoid overpraising them; but at the same time, they immediately sense it if they are underpraised. They ask that every word, to the letter, that is written, transmitted or said about them be relayed to them.

3. When a Diagnosis is Made

[Question] **Spending an entire year with another person in one room would be virtually impossible even if the other person were one's wife. How then do the cosmonauts manage to spend a year with one another? Do conflicts occur?**

Myasnikov: Yes. And psychological support is needed for this, too. But not only for this. Our first chance to make regular use of psychological support was during the mission of Yuriy Romanenko and Georgiy Grechko aboard the Salyut-6 orbital station in 1977. A very difficult situation arose: the father of Georgiy Mikhaylovich [Grechko] died. He was virtually the only person who was close to him. What was to be done? Should this event be reported to the cosmonaut and should he be granted the right to abort the mission? Or should he not be told? It was decided not to tell him. We gathered a group of technical supervisors, physicians, psychologists, and Grechko's relatives and devised all sorts of stories that would make it possible not to arrange for a communication between Georgiy Mikhaylovich with his father (although the cosmonaut constantly insisted on it) for the duration of the mission, which lasted 96 days. In general, we succeeded and were able to hold up for the entire 96 days. And when V. A. Shatalov broke the tragic news to him at the landing site, his reaction was favorable for us; the cosmonaut agreed that we had acted correctly. This was the first significant incident in the work of the regular psychological support group, its baptism, so to speak. Although psychological support per se was, of course, implemented from the very beginning, for the mission of Gagarin.

[Question] **Where there any incidents during the last, year-long mission?**

Myasnikov: Solidarity and interaction were very high throughout the mission of the V. Titov—M. Makarov crew.

[Question] **You mean there was not even a disagreement between them?**

Bogdashevskiy: Once there was something like a tiff. It lasted 3 days, and after that the cosmonauts resolved the situation.

[Question] **Did you detect this during the mission?**

Myasnikov: Yes.

[Question] **How?**

Myasnikov: We detected a change in the personalities of the cosmonauts. The diagnosis was made that something was wrong with the crew, that there had been a falling out. How did the psychological service act? You know that, among other things, we organize talks between the crews and their families. In essence, we have two interacting crews: the commander and flight engineer, in the spacecraft, and their wives, here on the ground. And in this case we had to resort to some tricks, we had to ask the wives to create a situation of forced interaction between the husbands through cross-questions. Emotionally, the conversation was so constructed as to break the ice.

Kozerenko: The wives also learn to understand the moods of their husbands long-distance. We did not even have to prompt them as to how to conduct a conversation to return them to a balanced state.

Myasnikov: They are the unofficial members of the psychological support group.

Bogdashevskiy: In general, it is hardest to resolve a conflict between cosmonauts. Of course, certain recommendations are offered to the crew commander as to how to act when relations between some of his crew members become acutely strained. However, he does not always have the opportunity to follow them and sometimes himself becomes the instigator of a conflict. In such a case, the "ground" has virtually no real way of affecting the situation. If we were to try to directly interfere with the commander's actions, we might not be helping him and, perhaps, might only be doing harm.

Kocherenko: I should like to mention another important detail. The psychological support service is also the last, so to speak, discharge valve to let off steam. It is a unique drainage system. For example, during the mission of V. Dzhanibekov and V. Kovalenko tension developed. And we opened the sluice, deliberately allowing them to shower criticism upon us. After all, it is impossible to pour out built-up irritation on other services, let alone management.

[Question] **Do you have some tests to assess the psychological status of a crew? Or do you assess it on the basis of general considerations?**

Myasnikov: We use expert evaluation. Although there are also formalized tests. But still, we prefer the assessment of experts.

[Question] **After a mission, do the cosmonauts remain friends, or can they not abide one another?**

Blagov: It varies. There are some who do not even want to undergo postflight rehabilitation together, who request to be sent to different sanatoria. And there are those who are as thick as thieves.

Myasnikov: There are fewer of those who are friends than those who merely tolerate one another.

[Question] **Has there ever been a cosmonaut who has said after one mission: "That's all, boys, I will never set foot there again!"?**

Bogdashevskiy: Of course not. There are some, however, who were told: "You shall never set foot there again!" Yes, there are those.

Botany Institute Studies Effects of Zero Gravity on Plants

18660152 Riga SOVETSKAYA LATVIYA in Russian 25 Jan 89 p 3

[Article by Rita Grumadayte, correspondent (Vilnyus)]

[Excerpt] One of the sections of the reentry vehicle in which Soviet cosmonauts Vladimir Titov and Musa Manarov and French cosmonaut-researcher Jean-Loup Chretien landed in the Kazakhstan steppe at the end of last year was 'reserved' by Lithuanian botanists. The crew brought scientists of the Lithuanian Academy of Sciences' Institute of Botany some long-awaited luggage—a container inside which were plants that had germinated on the spaceship.

Lithuanian biologists under the direction of academician Alfonsas Merkis, director of the Botany Institute and an eminent specialist in space biology, were studying space biology 20 years ago; they were among the first in the Soviet Union to do so.

The hypothesis has been confirmed that plants can live to the fullest and develop in conditions of zero gravity, even though all living things on Earth evolved under the influence of gravitation.

Specialists of the Botany Institute have also determined plants' threshold of sensitivity to the force of gravity. It has been found that plants, unlike human beings and animals, respond to even one thousandth or ten-thousandth of this force. Specialists are now studying changes which occur in cells during the process of formation of plant tissues and organs. This will be an aid to understanding biological features of the development of a living organism. The botanists have developed a series of instruments for growing flora in zero gravity. 'Space greenhouses' developed in Vilnyus were awarded a gold medal at an international exhibition in Plovdiv (Bulgaria).

FTD/SNAP

Study of Plant Tissue Culture Grown in Space

18660153 Vilnius SOVETSKAYA LITVA in Russian 11 Feb 89 p 4

[Article by Yu. Tubinis]

[Excerpt] Experiments in the field of 'space botany' are being conducted by Lithuanian scientists under the direction of Professor A. Merkis, an academician.

As is known, a flight in orbit on board the manned complex "Mir" continued for an entire year, for the first time in the history of cosmonautics. A tissue culture of an arabidopsis plant grown in space was returned to Earth. It turned out that in space, this culture did not spread out evenly over a surface but formed a ball. It is now being studied by specialists.

(Photograph shows Candidate of Biological Sciences R. Laurinavichyus, head of the Institute of Botany's gravitational physiology sector, working with a microscope.)

FTD/SNAP

Landing Tests for 'Buran' Shuttle With Jet Engine-Equipped Mock-up

18660154 Riga SOVETSKAYA LATVIYA in Russian 27 Jan 89 p 3

[Article by Stepan Anastasovich Mikoyan, General-Lieutenant of Aviation, Hero of the Soviet Union, meritorious test-pilot of the USSR]

[Abstract] The author, who is identified as a director of flight tests, comments on problems of controlling unmanned flights of the reusable spaceship "Buran" and landing it in a gliding mode, without the use of engine thrust. Particular attention is devoted to the use of an operating mock-up of the "Buran" in rehearsing landings and training pilots.

As compared with the "Buran" itself, this mock-up is said to possess features which ensure flight similar to that of a conventional airplane. The mock-up has four jet airplane engines which enable it to take off and climb to an altitude of 5-6 kilometers, for example, and it is equipped with a landing-gear retraction system and ejectable seats for two test-pilots. The mock-up is identical to the "Buran" in most other respects. The control systems of the two craft are similar, which enabled the mock-up to make 16 landings in the automatic mode.

During its initial flights, the "Buran" mock-up glided to landings along a conventional sloping path, using engine thrust, it is recalled. Landings without the use of engine thrust were subsequently executed, in which approaches were made along a glide path with manual control by the pilots. The correctness of flight paths which had been simulated with testing units was confirmed. The angle of the mock-up's glide was very steep (about 20 degrees), and its rate of descent was 50-60 meters per second. Leveling-out began at an altitude of about 500 meters, so that the aircraft's gliding angle would be 2-3 degrees at the moment it approached the ground. Two successive approaches were made in order to obtain more information that was needed. During the initial approach, the mock-up's engines were switched to maximum power at an altitude of 10-15 meters, and the aircraft then climbed to an altitude from which the second approach and a landing were made. Completely automated landings of the mock-up were not attempted until the aircraft's automation equipment had been tested in steep glides followed by manual landing.

The author relates that simulating equipment and laboratory airplanes were used constantly in the testing program. In the process of testing, partial changes were made several times in the mathematical program of the spaceship's onboard equipment. These revised programs were first rehearsed with testing units (including a full-scale simulator of the "Buran" mock-up) and then checked with the aid of a TU-154 laboratory airplane before being used in the control system of the mock-up itself. The mock-up's crews rehearsed assignments of each flight in advance, first with a flight-dynamics simulator and subsequently with a TU-154 airplane. This simulator is said to duplicate practically all of the cockpit and aerodynamic and piloting characteristics of the mock-up. More then 100 irregular situations and equipment failures which may occur during flight can be simulated with this unit.

FTD/SNAP

Development of Air Transport System for Energiya and Buran

18660162 Moscow KRASNAYA ZVEZDA in Russian 12 Apr 89 p 2

[Article by V. Burdakov, doctor of technical sciences, professor: "On the 'Back' of An Airplane: How Energiya and Buran Are Shipped to Baykonur"; first paragraph is introductory paragraph in source.]

[Text] **The creators of the Energiya rocket do not like it when their creation is called an ordinary rocket. In all of the planning and design documentation, it is called a "universal space-rocket transport system." This is not only a matter of technical accuracy of the formulation, but also of essence. A simple booster rocket is one thing; but a universal transport system is something else entirely, in planning, in the problems solved, in power capacity, and in design. Those who saw Energiya in the experimental assembly building, where it was assembled, or on the launch structure or who saw the launch (Central Television made this possible) were astonished by the size and performance of today's most powerful rocket. Many wondered how this rocket was brought to Baykonur if even its individual parts are so large. This question is discussed here today by one of those who participated in the creation of the Energiya-Buran system.**

In contrast to the traditional method of transporting the Soyuz, Proton, Cosmos, and Vertikal launch vehicles—as well as the strap-on booster units of Energiya—by rail, a fundamentally new means of transport had to be developed. It is sufficient to say that the central hydrogen unit, with a diameter of 8 meters, exceeds all conceivable size limits allowed by rail transport. That same problem had to be solved for the Buran spacecraft.

It is well-known that the Americans use a re-fitted Boeing 747 to transport their shuttle. The idea of transporting one aircraft on another was first implemented in 1931. Valeriy Chkalov, of the Air Force Scientific Research Institute, flight-tested the Zveno airplane designed by V. S. Vakhmistrov. The plane was an "aircraft carrier" with fighter planes attached to it.

Rocket tanks are very delicate cargo. They are thin-walled, non-rigid shells that have been designed for longitudinal, not lateral, stress, and the interior chamber must be kept absolutely clean. They are very expensive and not very streamlined. All those factors represented a major problem, since no precedent existed for such

operations in the world. That, by the way, was the main argument of many skeptics who battled those who advocated an unusual technical solution to the problem. Some of the alternatives that were examined even included the construction of plants at Baykonur itself, the laying of special wide-gauge railroad (or motor vehicle) roadbeds, the construction of a navigable canal leading to Baykonur, the development of a dirigible, and so on.

Idle talk? No. Each alternative had fervent supporters, and some projects were taken to the stage of experimental implementation—for example the linking of two Mi-26 helicopters.

A decisive role in the victory of the alternative involving transport atop an airplane was played by the famous general designer of aviation equipment, V. M. Myasishchev, and his closest colleagues, who promised to develop in an unbelievably short period of time a new transport airplane, the VM-T, based on a heavy strategic bomber.

At the same time, work was being carried out at the special design bureau of O. K. Antonov, who has experience in the creation of Antey-type transport aircraft. Oleg Konstantinovich was fiercely supported by those of his associates who were of the same mind. Later, organizational documents appeared which determined who would create the air transport system for moving the large structures of the Energiya-Buran system. Even now, by the way, many people think that the whole problem was solved by "aviators" only, without the participation of "rocket scientists."

Actually, the events developed quite dramatically. The greatest blow to us was the assertion by representatives of the Ministry of Aviation Industry that its plants could not produce a transport container. Why, we thought that that was their main job, since that type of container is essentially an aircraft fuselage. It turned out that now we ourselves have to make, instead of one whole fuselage, three fuselages—the number of loads to be transported.

We quickly discovered that the new superheavy airplane of Antonov's special design bureau would be, in its final form, six meters too short; it would have one central tail fin, and not two, as we had required; and it would only be able to transport the elements of the hydrogen unit that the VM-T could transport. Fearing the worst, we had to reach an agreement on all the conditions with regard to the VM-T. As for the heavy airplane (now known as Ruslan), several years of correspondence were spent trying to convince the subcontractor that produced the parts for us that it was necessary to increase the length of the fuselage and the lift capacity of the aircraft and to install two tail fins.

Jumping ahead in the story, we were finally forced to tackle the job ourselves of creating many elements of the first stage of the air transport system. By and large, all of the work was done by the enterprises of the Ministry of Aviation Industry and the Ministry of General Machine Building.

The technical solutions being developed had one goal—to deliver the cargo to the site and to keep the object being transported from being damaged. The largest object (in terms of dimensions) was the hydrogen tank, which had to be equipped with a detachable transport frame with fittings for attachment to the airplane, a forward fairing, and a tail cone, to give it an acceptable aerodynamic configuration.

The hydrogen tank was filled with nitrogen and hermetically sealed. Pressure was continuously monitored in flight by a measurement system. The readings from that system were transferred to the cabin of the airplane on a separate panel. Skills associated with reading the panel and with the actions of the crew in a critical situation—in the event of a possible loss of the hermetic seal—were the object of a special test for the flight crew. And not by chance, for if that occurred, it would become impossible for the aircraft not only to land, but also to descend. With the gas escaping, the rapidly growing external pressure could not be counteracted. And the tank, losing its shape and contracting, would inevitably lead to the loss of not only the cargo, but also the plane.

Great precautions were taken when the mock-up tank was being pressure-tested with gas, so that no explosions would occur, but everything, as they say, went O.K.

Yet another characteristic of the cargo was that the fairing and tail cone were hollow and not hermetically sealed. However, their lack of such a seal, unmonitored, could have the same effect when the plane descended as a gas leak in the tank, that is, the aerodynamics of the cargo would be violated, and the airplane would crash. To prevent this, the fairing and tail cone were designed so that they would be aerodynamically filled by the oncoming airflow channeled in through special air intakes.

To balance the load, bags of sand were provided. The acceptable variation in the position of the center of mass was no greater than 25 centimeters. And that is with a mass of 82 tons and a length of about 45 meters!

The PKU-50 gantry crane, which can lift up to 50 tons with two pantograph-grippers and can make precision movements along a railed path and across the axis of the cargo, is a unique structure capable of rigging loads that have immense "sailability" and accurately joining the attachment points of the cargo and the airplane at wind speeds of up to 15 meters per second.

The first fitting sessions showed that the unusual loading operation is unique. The riggers had to work 3-5 stories high. The wrenches, pins, and equipment necessary for work had to be securely fastened on special halyards, because if they fell, they could damage the airplane.

Finally, all the equipment was in place. Now vibration-frequency testing had to be conducted. The N. Ye. Zhukovskiy Central Aerohydrodynamics Institute has special vibrators and measurement equipment for that. All the types of cargo and the airplane were submitted individually to the "execution." Then the plane was tested with a cargo atop its back. Without exception, all of the variations for using external suspension to transport the units and assemblies of the space system were tested.

And then the day of the first test flight arrived. It was winter in Moscow. Consequently, there was yet another danger—namely, icing. Even a five-millimeter layer of ice on the front surface of the cargo (and in the right atmospheric conditions, that layer forms in a few seconds) could cause a crash. You see, that thin layer weighs, according to the most modest estimates, about 800 kilograms. Once it is formed, it shifts the center of mass of the cargo forward—and the plane's rudder cannot compensate for this.

How did the flight itself go? First, a Tu-134 chase plane took off and made several "ranging" passes over the runway. Once this maneuver was mastered, as the Tu-134 made its next pass, the VM-T with its cargo began to accelerate. The speed climbed higher and higher. The anxiety of the crew, the flight controller, the many people involved with the flight, and the "audience" was at its peak.

Finally, the front strut of the bicycle landing gear came off the ground, and the plane almost immediately lifted off the runway. A small tilt to the side, characteristic of planes with bicycle landing gear, was not dangerous at all, but caused some novices to gasp involuntarily. The unusual aircraft—the object, later, of the most unimaginable stories among local inhabitants—and the trail of dark smoke from its engines disappeared from sight.

The flight continued as follows. Flying over the Moscow River, which was not yet frozen, the plane got caught in an updraft, which shook its tail assembly. The crew heard scraping and creaking in the tail section. There were fields below, with a small wooded area. The commander of the ship, A. Kucherenko, gave the crew the command to be ready to abandon the craft. The chase plane was ordered to describe approximately the extent of the deformation. Reports flew in the air. The fuselage was twisted at a large angle, and this was determined visually (later interpretation of the records showed that this angle was completely acceptable and ten times smaller than reported!).

The oscillation stopped as quickly as it had started. However, the troubles were not yet over for the flight. The flyers suddenly became aware of a rhythmic, dull pounding coming from the direction of the cargo. A thought flashed through the minds of the crew: "One of the fasteners has broken loose." That would be a catastrophe. But the pounding continued, and nothing happened to the aircraft. The crew of the observation plane (to whom we are grateful for the photographs that we have here) reported to the control tower and to the VM-T that one of the pieces of tape securing the mock-up thermal insulation had come off. The tank had "shrunk" because of the decreased outer temperature, and the tape broke and began to flap, spontaneously tying itself into a huge, tight knot. That is what was beating on the tank. The first test flight, which went in a circle and lasted less than an hour, ended safely.

Later, there were other, more complicated flights. The first test of the plane with another cargo (an oxidizer tank and the forward and aft sections of the hydrogen rocket unit) went smoothly. The following flights also went smoothly. Processing of the material obtained proved that all the design decisions had been correct.

And so regular transport of all the large elements of Energiya and Buran to Baykonur began ahead of schedule. It should be noted that the creation of a unique transport system was made possible by the participation and the support given to all our undertakings by G. Ye. Lozino-Lozinskiy, I. N. Sadovskiy, V. M. Filin, A. D. Tokhunets, and many other specialists of the Ministry of Aviation Industry and Ministry of General Machine Building.

And so another extremely complex problem has been solved. But we have not dotted all the i's yet. A new superheavy airplane, the Mriya, has been created and is being tested. It can deliver large-tonnage, oversized cargoes over great distances (structures of up to 10 meters in diameter can be placed atop its fuselage). In a word, improvement of the air transport system continues. And that system not only is needed in the development of spacecraft, but also has broad applications in the national economy of the country.

UDC 629.782

Quality Indices Exchange Diagram for Joining of Spacecraft Approach and Docking Trajectories in Nonstandard Situations

18660133b Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 26 No 6, Nov-Dec 88 (manuscript received 31 Mar 87) pp 946-949

[Article by N. S. Gubonin]

[Abstract] This is essentially a continuation of an article by N. S. Gubonin, et al. in KOSMICH. ISSLED., Vol 15 No 2, 1977. It is shown that the probability of collision P_c and an inadmissibly great separation P_{scp} can be

regarded as quality indices for the joining of spacecraft approach and docking trajectories under the condition that the approach stage has been successfully completed but in the docking stage there is a lag in onset of control by the time τ caused by search for and elimination of a malfunction in the control apparatus failing at the moment of transition to docking. The τ parameter or the probability P_n of noncorrection of the malfunction during the time τ unambiguously related to it characterize the quality of the automatic system for diagnosis and elimination of control apparatus malfunctions. The purpose of this article is to establish a functional relationship (exchange diagram) between the P_c, P_{sep}, P_n indices. A knowledge of the exchange diagram makes possible a rational distribution of the requirements on these indices, and as a result, the setting of requirements on the accuracy characteristics of the control system in the approach stage, on the effective range of the docking apparatus and on the characteristics of the built-in apparatus for control and elimination of malfunctions. Figure 1; references: 3 Russian.

UDC 629.78.015

Magnetic Hysteresis Damping of Vibrations of Satellite With Large Magnetic Moment

18660141a Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 10 Jun 87) pp 25-30

[Article by M. L. Pivovarov]

[Abstract] The rotation of a satellite with a permanent magnet in the plane of a polar Keplerian elliptical orbit is examined. A direct dipole model is used to describe the Earth's magnetic field, and a magnetic hysteresis rod to study damping. The period of motion of the satellite relative to the magnetic force line is assumed to be substantially smaller than the orbital period. With no constraints on the shape of the hysteresis loop, averaging is used to produce analytical expressions of the energy of rotation of the satellite relative to magnetic field force line, the time of transition from a regime of rotation to a regime of vibrations, and the amplitude of the vibrations. Figures 1, references 4 (Russian).

UDC 629.197.23.332.80

Optimization of Trajectories and Parameters of Interorbital Transport Craft With Low-Thrust Engines

18660141b Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 18 Mar 87) pp 42-53

[Article by S. A. Ishkov and V. V. Salmin]

[Abstract] Interorbital transport systems are designed to transfer payloads from low orbits to rather remote working orbits. A promising direction in the development of such transport systems is the interorbital system powered by ion-plasma jet thrusters, which would be used to haul large structures—solar power stations, radar antennas, and radiotelescope elements, for example. Such a system, however, would itself be large and heavy, and with lengthy powered-flight (100-200 days) and the difficulty of control with the thrust vector of the engines, new methods of ballistics-planning analysis are needed for such vehicles. The methods must optimize ballistic flight configurations, the principles of control of trajectory and angular motion, and the parameters that determine the externals of the control of motion loop, including the craft's power plant and its propulsion system. With flight trajectory essentially a function of the craft's design parameters and the parameters of the control configuration, the researchers advance an iterative procedure for optimizing both areas. In the process, the dynamics of the craft relative to the center of mass and the additional fuel expenditures needed for controlling the craft are taken into consideration. Figures 5, references 7 (Russian).

UDC 629.78

Mathematical Basis of Theory of Orbital Correction Performed With a Solar Sail

18660141c Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 22 Nov 85; final draft 3 Feb 88) pp 54-63

[Article by Ye. N. Polyakhova, A. S. Shmyrov]

[Abstract] The authors examine a problem involving correction that uses the low thrust of a solar sail to suppress perturbations of the geocentric orbit of a spacecraft. The problem involves a fixed orbital plane, with three correctable elements. The spacecraft is also taken to move in the plane of the ecliptic at an altitude close to the altitude of a diurnal satellite, which means that the effects of the Earth's shadow and of atmospheric resistance may be disregarded. The solar sail is taken to be reflective on both sides, and, over the course of a year, it moves in a parallel, uniform light flux. The orbital perturbations that must be suppressed are included in the boundary conditions for the orbital elements. The only disturbing force is the force of the light pressure of solar rays on the sail, a force that here is smaller than the central attractive force of the Earth. The researchers use methods of perturbation theory of classical celestial mechanics. The light pressure is used as the thrust for performing necessary orbital corrections. The mathematical underpinnings of the problem involve investigation of a nonlinear controllable system of equations of the fourth order, but the combination of averaging and perturbation theory make it possible to find an approximate optimal solution for it. Assessments are made of the nearness of the solution to the optimal. The problem is considered for any baseline conditions in terms of orientation of the line of apsides and the dimensions of

the elliptical orbit, with fixed constraints on the thrust of the solar sail that regulate the relationship of the perturbation and the rate of change of solar longitude. References 8 (Russian).

UDC 65.012.2:629.198.3

Software for Automated Support of Research Aboard Mir Orbital Complex

18660141d Moscow KOSMICHESKIYE ISSLEDOVANIYA in Russian Vol 27, No 1, Jan-Feb 89 (manuscript received 26 July 88) pp 54-63

[Article by M. Yu. Belyayev, S. G. Zykov, A. I. Manzheley, D. N. Rulev, V. M. Stazhkov, and V. P. Teslenko]

[Abstract] Unlike the Salyut station, the Mir orbital complex uses gyrodynes to effect the control of motion required for conducting onboard research. The spacecraft must maintain an attitude that ensures proper pointing of scientific gear toward an object, as well as favorable conditions for gyrodyne operation and enough sunlight for the solar batteries. To do this, and to prevent gyrodyne "saturation" and power shortages and ensure uninterrupted radio communications during certain experiments, researchers developed a special software package that runs on PCs and that has been used daily as part of the Kvant module for on-line flight support. The software performs preliminary planning and preparation of dynamic systems for conducting experiments and for performing flight operations. It provides forecasts of the functioning of the systems of the orbital complex that affect the performance of research, optimizes research programs on the basis of various criteria, and handles the information needed for the operation of onboard servo systems and scientific gear. Program packages are also included for performing such tasks as determining the angular position of the complex from telemetry measurements, handling the information needed for interpreting the results of scientific experiments, and computing the corrections that need to be made in the scientific gear and the complex's attitude control instruments. Figures 3, references 6 (Russian).

Numerical Estimation of the Secular Effects in the Translational-Rotary Motion of An Orbital Station With Artificial Gravity

18660145 Dushanbe DOKLADY AKADEMII NAUK TADZHIKSKOY SSR in Russian Vol 31, No 10, Oct 88 (manuscript received 6 Apr 88) pp 644-646

[Article by D. Z. Koyenov, Tadzhik State University imeni V. I. Lenin]

[Abstract] An orbital station represented by two spheres that have an identical radius, are connected with a long cable, and rotate around an axis that passes through their common center of mass is examined. Rotational motion is around the nutation axis. The distance between the spheres is set at 200 km, and the radius at 100 m. The mass of each is 10^6 kg. The center of mass of the station moves around the Earth with the following parameters: perigee above the Earth, 500 km; apogee, 1000 km; longitude of angle of ascension, 45°; angular distance of perigee from node, 30°; orbital inclination, 57°; and $\tau = 0$, passage through perigee. The numerical values found for the coefficients of the secular members of the Delaunay elements (six were used to assign translational motion) indicate that the average anomaly of the center of mass of the orbital station over each mean solar day grows by roughly 5179°.25, which means that in one mean solar day, the orbital station completes more than 14 revolutions around the Earth. The numerical values for the coefficients of the secular members of the angular distance of perigee from the node and the longitude of the angle of ascension are neglible. Figures 1, references 1 (Russian).

Program to Employ Space Program Spinoffs in National Economy

18660127 Moscow IZVESTIYA in Russian
31 Jan 89 p 2

[Interview with Stanislav Petrovich Polovnikov, director of the "Kompozit" Scientific Production Association, doctor of technical sciences, by IZVESTIYA correspondent S. Leskov, under the rubric "Advice: Power and Practice": "The Ispolkom's Launch Into Space"]

[Text] **A program of cooperation between Mosgorispolkom [Moscow City Executive Committee] and "Kompozit" NPO [Scientific Production Association] has been planned to solve the city's top-priority economic development problems in 1989-1991. Similar programs have been approved at the USSR Ministry of Health and the Ministry of Installation and Special Construction Work. S. P. Polovnikov, general director of the "Kompozit" NPO and doctor of technical sciences, tells how space technology and materials science will be used in the national economy.**

Leskov: **Stanislav Petrovich, whole volumes have been written about the possibility of using the achievements of the space program in our "terrestrial" life. Unfortunately, until recently, when it came to specific examples of the application of advanced space technology in ordinary production, one most often had to cite foreign experience. Illustrations of this are the $25 billion invested in what was, at first glance, a big money-loser, the Apollo program, spinoffs from which brought companies a $75 billion return. Our space program, to put it mildly, is no slouch either when it comes to technological achievements. Some of them occasionally "descend to Earth," but most are kept sealed in space design offices.**

Polovnikov: Indeed, until recently we avoided broad promotion of the acquisition of special technologies that could be used in the national economy. Nevertheless, they have been introduced and have produced some effect. An example are light, high-strength alloys developed under the direction of I. N. Fridlyander, thanks to which we have hydrofoil passenger ships and modern passenger aviation. There have been calls to make wider use of advanced experience, but they have not been bolstered by an economic mechanism. With the sector's transition to cost-accounting, enterprises can't make do with budgeted funds only; they need their own money, hard currency. Therefore, we readily responded to Academician V. S. Avduyevskiy's suggestion to contact Mossovet's [Moscow City Council's] Main Administration for Science and Technology. Mossovet's chairman, V. T. Saykin, supported the plan. Mossovet will help conclude mutually beneficial agreements and will allocate additional space. I won't conceal the fact that one factor encouraging the collaboration is the prestige involved.

Leskov: **No matter what, you have to start almost from ground zero. However, you're literally starting out in high gear: The plan for joint work has less than ten general points, but you have to assimilate millions of rubles in 1989. Aren't you being too ambitious?**

Polovnikov: You understand, of course, no one forced us, there was no order from above, and the plans have therefore been calibrated and are quite realistic. As an example let's take a concern of everyone: health care. Tendons and ligaments, artificial vessels, and eardrums can be produced on the basis of a special carbon material developed in the USSR. In terms of basic medical parameters, such as resistance to clotting, the material is two to three times better than Soviet lavsan [Dacron] and American Fluorlon.

We've set up cooperation with the Central Institute of Traumatology and Orthopedics to develop new materials for endoprosthetics and materials on a qualitatively new level for medical instruments. Extensive use of composite materials in this area will reduce treatment time by a factor of 3-5 and make it possible to perform unique operations and to restore people's capacity to work where it was recently considered complicated or impossible. So that you don't think that this is a matter for the distant future, let me say that a successful operation was performed at the Central Institute of Traumatology and Orthopedics in which implants made of a special high-strength steel and developed for rocket engines were used. Production of "spare parts" for humans is already beginning this year.

We are providing tremendous assistance to transportation in the capital. Here our common interest basically pertains to noncombustible materials. It is a real misfortune that the flammability of the paneling of trolleys and subway trains makes them flare up like candles. This is a problem that the space program has overcome.

A painful issue about which much is being said now is the construction of the new Rzhevskiy Reservoir for this big city's ever growing needs. Naturally, ecologists have risen up against it. There are many arguments in the debate, but has anyone considered how much water the capital loses because of poor quality plumbing? We can't imagine a faucet that doesn't leak or drip. Every faulty faucet wastes 40 cubic meters of water a year! But threaded faucets fell into disuse abroad years ago. They have been replaced by ceramic plates fitted to one another. We are familiar with the technology for shutoff fixtures, and organizing its mass production isn't that complicated.

Certain points in the collaboration seem exotic at first glance. Such as the meat-cutting knives we will supply to the 2nd Moscow Meat Combine. Given the acute shortage of meat, about 20 percent of the product is now lost because of poor quality knives—they quickly become dull and crush and shred the meat. The use of the high-strength steel used in rocket engines sharply

increases the quality of ground meat. These knives are already as good as those in West Germany, which are officially considered the world's best.

The plan for cooperation with Mossovet also calls for the start-up of production of sewer and gas pipe made of longer-lasting, stronger materials; heater panels; and hard steel teeth for breaking up old asphalt paving (a long-held, unrealizable dream of our roadbuilders); and, in the construction sector, supply of units to apply foam plastic to joints and cracks in prefabricated buildings. In the last instance, by the way, certain approaches used in the "Energiya" booster rocket have been used in a simplified way. The units are in great demand; they have already been requested by about 60 domestic enterprises. In response, we're getting the necessary help in housing construction.

Replacing the very scarce stainless steel used for coating various kitchen utensils, vats, tanks, and storage containers for grain and liquids with the polymer composites used in rocket technology is of great importance to the agricultural industry and local industry.

Leskov: **It's regrettable that these achievements come to the national economy after so long a delay. All the more important to study the motives for collaboration. As I understand it, the motive force for you is reciprocal supply of scarce products and a sense of moral satisfaction. That is still far from the ideal—a genuine economic mechanism for applying the achievements of the space program. The need for that is acute, not only here: NASA's budget has a clause for "commercial use of space," to which $30 million was allocated in 1986. What production capacities will be used to develop the essentially new sector?**

Polovnikov: I think that we need to take two paths. To use the capacities freed as a result of the destruction of medium-range rockets, and to more boldly use the new technology to rebuild enterprises that now produce obsolete products. Theoretically, any enterprise can set up an area to produce parts made of composites.

Leskov: **The materials you're talking about, Stanislav Petrovich, have been developed and produced on Earth. The problem of expanding their applications is being solved. But we've been talking a rather long time about orbiting factories. Even Tsiolkovskiy dreamed about them. Is there a real possibility of spinoffs in the national economy that consist of materials that are developed in space laboratories and have physical characteristics fundamentally different from terrestrial materials?**

Polovnikov: The press has repeatedly published descriptions of experiments in space to produce new substances and materials. I believe that the beginning of production of medicines and biological substances in orbit is the most realistic of all the various areas of space materials science in the near term. It is more complicated to set up production of parts for microelectronics, which requires a great deal of energy and the almost total absence of any kind of accelerations. Weighing these circumstances, I would say that it is quite realistic that by 1995 we'll increase space production to 3-5 billion rubles a year.

Leskov: **And so NPO "Kompozit" has outlined a plan for collaboration with Mossovet. But despite its diversity, the capital's economy apparently does not begin to represent all the sectors which could take advantage of the achievements of space technology and materials science, does it?**

Polovnikov: Quite right, but for now, unfortunately, cooperation with enterprises across the country is only sporadic. For example, in 1975 the Voskresensk Combine installed a 120-meter pipe made of composite material. The pipe has performed without trouble since that time and requires no maintenance. The savings has amounted to more than a million rubles. A high-capacity gas conduit has also been produced for the Dorogobuzhskiy Plant, and the savings there has grown to several million. Refinements in Voronezh excavators made with the help of one of the design offices have sharply increased the engines' efficiency.

But that is, unquestionably, only a little in terms of the possibilities. According to all statistical handbooks, the USSR is proudly starting up huge metal smelting capacities. But is it good to plug all the holes in the economy with scarce metal? In many cases (pipes, tanks, reservoirs), the West long ago rejected metals in favor of ecologically clean composite materials. Do proposals to erect giant integrated metallurgical plants that convert irreplaceable raw material and strike a violent blow against natural systems really make sense? By comparison, last year the USA produced 150,000 tons of composites; we produced 2,000. Given this ratio, the goal of catching up to advanced countries is unrealistic; nevertheless, we must approach the world level. By 1995 the Americans will approach 180,000 tons, and we can achieve 60,000 tons. Initially, this goal will require major capital investments. But we can't stint, since the effectiveness of introducing polymer composites into the national economy with a production output on the level of 200,000 tons by 2000 is estimated to be 41 billion rubles.

Leskov: **Stanislav Petrovich, the juxtaposition of space equipment and sports equipment in your association's production shops looks a little strange. Steeplechase barriers and sporting canoes—do your associates need this equipment to limber up?**

Polovnikov: We have nothing against exercise, and we spend a considerable portion of the money earned under various agreements on our health complex. However, in this instance you saw fiberglass products for equestrian competition. It was recently tested at Bittsa. It was proven that, unlike wooden rods, when struck by a hoof, the fiberglass barrier doesn't break or pose a threat of

injury to the rider or horse. By the way, it used to be that steeplechase barriers were acquired abroad at a cost of 50,000-60,000 gold rubles, but we make them from primary production wastes.

Leskov: **Stanislav Petrovich, a very idyllic picture emerges from your story. It's hard to believe that you haven't encountered any difficulties in this new enterprise...**

Polovnikov: When we undertook spinoff work, it was discovered that the leaders of many sectors were entirely ignorant of the capabilities of modern technology and materials science. But that isn't their fault; it's just a misfortune—our sector has been a closed one for so very long. To be brief, we've noticed a pattern. The higher the manager who comes to us, the more enthusiastic the response, the more persistent the proposal for cooperation. But little by little, this desire fades, and when it comes to a specific design office, we often encounter an unwillingness to change the status quo, to lower the price of the product. The new economic mechanism has only just begun to operate. I think it will bear good fruit in the near future. There is no question that new materials aren't cheap today. At first glance, their use seems unprofitable. But world practice has shown that prices drop sharply as use increases.

Leskov: **The abundant data on composite materials that your enterprise and related enterprises have at your disposal need to be systematized. How would a potential partner who would want to collaborate with you know about the new materials?**

Polovnikov: A computer center with a large data bank has been created by order from higher organizations. It stores information on 300,000 different characteristics of materials. Mathematical models of processes which develop in the materials under different loads are are being developed on the basis of the data bank. We're ready to acquaint all our colleagues with this data bank. We've already begun negotiations with a number of enterprises on creating an information network across the entire country.

'Raduga' Communications Satellite Launched 14 April

LD1504072589 Moscow TASS International Service in Russian 0653 GMT 15 Apr 89

[Text] Moscow, 15 Apr (TASS)—The launch of the latest "Raduga" communications satellite with on-board retransmitter equipment was carried out in the Soviet Union on Friday [14 April] with a "Proton" carrier rocket. It is intended for ensuring telephone-telegraph-radio communications and for transmitting television programs.

The "Raduga" satellite has been put into an orbit which is close to a stationary one with the following parameters:

—distance from the earth's surface: 36,523 km;
—period of rotation round the earth: 24 hours, 34 minutes;
—inclination of orbit: 1.4 degrees.

The equipment installed on the satellite is operating normally.

The command and measuring complex is controlling the satellite. Operation of the communications and television equipment of the satellite will be carried out in accordance with the planned program.

Work on Satellite Navigation System Discussed

LD1304104589 Moscow TASS in English 0955 GMT 13 Apr 89

[Text] Moscow April 13 TASS—The Soviet Union has started the working out of a long-term communication, navigation and monitoring system on the basis of satellite communication. The work is being carried out by specialists from the Research and Experimental Center of Automatic Air Traffic Control. They believe that the system will permit to substantially improve the safety of flights.

"The satellite communication and navigation system is a group of satellites launched in such a way that the planes of their orbits form an angle with regard to each other. This ensures a range of observation covering the whole of Soviet territory", Vladimir Oreshin, head of a sector at the Center, told TASS. "Using the satellites, plane crews will be able to maintain radio communication with ground services and to accurately find their bearings. The new system will have a number of advantages over the existing one. At present long-distance communication with crews depends too much on the weather, the relief and other factors making more difficult the piloting of planes. Satellites permit to overcome these difficulties".

According to Vladimir Oreshin, the putting into practice of the new system will help improve the performance of the search and rescue services. For instance, in case of forced landing a satellite can communicate the exact coordinates of the plane, which will permit rescue teams to promptly arrive at the accident site. A satellite can control the functioning of all the units and instruments on board a plane. If any of them fails, specialists from the ground services will be able to promptly give recommendations on how to repair it. If this cannot be done, the satellite will help to quickly receive permission for an emergency landing at one of nearby airfields.

The new system will also permit to expand the range of services rendered to Aeroflot passengers. For instance, they will be able to speak over the telephone with any telephone subscriber in the country. The economic effect of these of satellites will be even greater because there

will be no need to maintain numerous radar stations for monitoring flights over the extreme north regions of Siberia, or to employ numerous specialists for servicing them.

The parametres of the system meet the requirements of the International Association of Civil Aviation (ICAO), a TASS correspondent was told at the Center. This opens up new opportunities for cooperating with other countries in this sphere.

New Satellite Broadcast System 'Moscow Global'

PM2404160189 Moscow SOVETSKAYA ROSSIYA in Russian 21 Apr 89 First Edition p 6

[N. Dombkovskiy article under the rubric "Reporting the Details": "World Watches Moscow. Global Satellite TV System Has Been Set Up"]

[Text] So, now there is virtually no place left on earth which cannot receive television broadcasts from Moscow. Tests of the new communications and television broadcasting system, called "Moscow-Global" by its designers, have been completed successfully. The Moscow "Radio" Science and Production Association headed and coordinated development work and Yu.B. Zubarev, USSR deputy minister of communications, led the work.

As is well known, today more than 95 percent of our country's inhabitants can watch Central Television's first program, and 85 percent can watch the second program as well. To a considerable extent the "Orbita," "Ekran," and "Moskva" satellite television systems are helping this. But this is in USSR territory while our compatriots live and work in dozens of countries and also want to know about events at home.

Soviet missions in some places in Europe, North Africa, and to some extent Asia have satellite television receivers, but this is just a drop in the bucket. "Moscow-Global" was set up to make it possible to watch Moscow in any part of the world.

The basis of the system is two series-produced "Gorizont" satellites launched into geostationary orbit. This means that they orbit the earth in 24 hours, moving in the direction of the earth's rotation. So the result is that the satellite "hangs," as it were, over the same point. This is very convenient—you can train an antenna on it and not worry that the satellite "will disappear" from its field of vision.

The first satellite, which has a "Statsionar-11" identification code, is over the equator at 11 degrees west. The second is at a point 96 degrees and 30 minutes east. There is no place on land that cannot receive broadcasts from these satellites.

Special receivers are being produced to work with the satellites. A small—relatively speaking, of course—antenna, 4 meters in diameter, and a small container which fits easily in a small truck—that is all.

Naturally, similar apparatus is also produced in other countries, but there is still nothing similar in the world to "Moscow-Global," and the reason is this. In addition to one television channel in color, it makes it possible to broadcast a high-quality radio service and it has a separate high-capacity communications channel. So any Soviet embassy or mission will be reliably linked with the motherland.

Incidentally, the communications channel is particularly convenient for diplomats and our journalist colleagues from TASS, APN, and State Television and Radio—they will be able to obtain information promptly from the Foreign Ministry and their main editorial offices.

Series production of ground stations for "Moscow-Global" began this year. Before the end of December 20 sets will have been produced, and from next year the manufacture of these stations will increase significantly. The approximate cost of the stations is R130,000.

Soon it will be possible to see "Moscow-Global" at the USSR Exhibition of National Economic Achievements.

Test of U.S.-USSR Satellite Communication Channel for Information Exchange

18660156 Moscow IZVESTIYA in Russian 18 Jan 89 p 5

[Article by I. Andreyev]

[Excerpt] Testing of a high-speed Moscow-San Francisco computer channel for satellite-aided communications is being completed.

At the Soviet 'end' of this channel is the All-Union Scientific Research Institute of Applied Automated Systems (VNIIPAS), which also performs functions of a national center for automated exchanging of information with foreign computer networks and data banks. At the American end is a noncommercial organization, "San Francisco-Moscow Teleport".

"By obtaining access to a data bank in the USSR or abroad, with our assistance, any so-called information user—and there are tens and hundreds of agencies and organizations among them—can obtain 100-150 documents an hour on their display screens," said Doctor of Technical Sciences, Professor O. Smirnov, director of VNIIPAS.

"Via VNIIPAS, Soviet users in many cities of the USSR can obtain access to computer networks abroad, and foreign subscribers can obtain access to ours. There are computer communications with the capitals of all of the socialist states and of two capitalist states—Vienna and

Helsinki. Through these two channels we also obtain a through connection, so to speak, to any world system or any world bank of data, wherever it may be. There is a charge for the service, of course, and payment must also be made for through connections, which are not always simple, single-stage ones. It has been necessary to simplify such two-way communication—with the aid of an American "Intelsat" satellite in this case—and make it less expensive, because Soviet and American organizations are exchanging information more and more often in large amounts.

"Specialists of ours have left for a Soviet satellite communications center at Medvezhi Ozera in suburban Moscow. A communications channel has already been built from our institute to this center. By electronic mail, we have received confirmation from American specialists that they are ready for the final stage of tests."

FTD/SNAP

Comment on Photography of Antarctica by 'Cosmos-2000' Satellite

18660155 Moscow SOVETSKAYA ROSSIYA in Russian 12 Feb 89 p 1

[Text] The jubilee satellite "Cosmos-2000", which was launched on February 10, will photograph the central part of Antarctica for the first time.

Commenting on this event, Yu. Kiyenko, general director of the State Scientific Research and Production Center "Priroda", said: "Placing of a spacecraft into a polar orbit is a complex technical task. Although 'Cosmos-2000' was placed into an orbit with an inclination of 82.3 degrees, photographic methods which have been perfected at our center will make it possible to take in the whole surface of the continent.

"Photographing of Antarctica from the spacecraft will be about one-eightieth as expensive as aerial photography would be. After all, this continent is about 14 million square kilometers in area. Pictures obtained by 'Cosmos-2000' will make it possible to accomplish an important task—mapping the central part of Antarctica in detail. Unique information on ice cover, outcrops of rock on the surface, and formation of glaciers and icebergs will also be obtained. We may succeed in adding to our knowledge of the mechanism by which the ozone 'hole' forms over Antarctica.

"In addition to research of the Antarctic continent, studies of natural resources and ecological conditions will be conducted, and photographing for the purpose of mapping many areas of the USSR is to be ensured."

FTD/SNAP

UDC 551.46.0:629.78

Method for Interpreting Remote Sensing Data for Land Surface Waters in Visible Spectral Region

18660112 Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 303 No 2, Nov 88 (manuscript received 12 Apr 88) pp 333-336

[Article by K. Ya. Kondratyev, academician, A. A. Gitelson and I. Yu. Kamov, Limnology Institute, USSR Academy of Sciences, Leningrad; Hydrochemical Institute, Rostov-na-Donu]

[Abstract] The objective of the study was to develop a method for interpreting remote sensing data obtained in the visible spectral region on the state of landlocked surface waters without the use of reference information. Underlying the method is the fact that the main contribution to light scattering at 180° and back is made by the mineral suspension in surface waters; the proportion of scattering by water and other substances is two orders of magnitude less. (Absorption is determined for the most part by phytoplankton and dissolved organic matter [DOM]). Information on the brightness of ascending radiation obtained by remote sensing is related to concentrations of optically active substances characterizing the quality of surface waters in terms of the spectral brightness coefficient, which can be determined directly by remote sensing. A matrix method is proposed for solving the problem. It is shown that space survey data make it possible to determine the mean concentrations of chlorophyll and DOM and their relative changes in a given area of water when certain a priori information is available, without the need for data on the concentrations of ingredients. References 4: 2 Russian, 2 Western.

UDC 574.9:550.3

Terrain Processing of Space Images for Biospheric Data Bank

18660086 Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 304,No 2, Jan 89 (manuscript received 15 Oct 87) pp 444-447

[Article by V. V. Bugrovskiy, O. B. Butusov and V. M. Dubovskikh,USSR Technical Documentation Scientific Research Center, Moscow]

[Abstract] The need has arisen for organizing environmental use data centers. The centers are needed in effective planning and prediction of the dynamics of natural systems affected by natural and anthropogenic factors. It is suggested that the functional systems at such a center include means for interaction with an environmental use data bank. Such a data bank should have a multilevel structure, the basis for which would be a regional terrain chart that provides geographical correlation of all the information stored in the various levels (such as vegetation, farm lands, population centers, road network, industrial facilities). Landforms (mountains, valleys, rivers, lakes) are conveniently stored in the

computer memory in the form of polygons or broken lines, which retains their visual images. A noise-immune generalization algorithm is described for eliminating distortion. The stages of terrain processing of space-derived images are examined: choosing the area of interest, determining boundary points, linking contours, generalizing the contours, comparing the generalizations with data bank reference information. The use of simply structured references in the data bank make possible a considerable reduction in the time required for image processing and a smaller computer capacity. The information contained in the data bank and the information represented in the space image mutually supplement each another, resulting in a synthesis of a static model of a natural feature which can be used in dynamic models for predicting use of the environment. Figures 4; references: 4 Russian.

UDC 551.583:341.12

Analysis of Earth Radiation Budget Observation Data

18660138a Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 89 (manuscript submitted 7 Dec 87) pp 3-16

[Article by G. I. Marchuk, K. Ya. Kondratyev, V. V. Kozoderov, Institute of Limnology, USSR Academy of Sciences, Leningrad; Department of Computer Mathematics, USSR Academy of Sciences, Moscow]

[Abstract] The need for a more profound understanding of climatic factors and climatic variations stimulates the interest in the data of observations of the Earth's radiation budget. Data collected in 1974-1978 suggest that the existence of energy-active zones in the World Ocean points to the effect that ocean surface temperature anomalies have on global atmospheric circulation and climate. In providing an analysis of the principal components of covariational matrices of anomalies of average monthly fields of the radiation budget, the authors here examine data that includes continuous 42-month NOAA observations made from June 1974 to November 1977 and Nimbus-7 data collected over a 60-month period extending from December 1974 to November 1983. They explore the possibility that the radiation budget drives atmospheric and ocean dynamics. Results are presented from an analysis of the principal components of average monthly fields of outgoing long-wave radiation in 5° intervals of latitude and longitude, and perturbations are described for those fields with typical horizontal scales of approximately 2,500 km. Figures 2, references 28: 14 Russian, 14 Western.

UDC 528.8:519.21

Fractal Dimensionality of IR Images of Cloud Cover and Properties of a Turbulent Atmosphere

18660138b Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 89 (manuscript submitted 28 Jul 87) pp 17-26

[Article by Yu. S. Baryshnikova, G. M. Zaslavskiy, Ye. A. Lupyan, S. S. Moiseyev, and Ye. A. Sharkov, Space Research Institute, USSR Academy of Sciences, Moscow]

[Abstract] Riding the success in recent years of the broad application of fractal dimensionality in fields as diverse as economics, chemistry, biology, and physics, investigators at the Space Research Institute used an algorithm to study satellite images of the tropical cloud formations that preceded the emergence of typhoons. The algorithm, which they had developed, was designed to calculate fractal dimensionality from IR images of cloud cover. The researchers found that there were a greater number of ordered motions in cloud formations from which typhoons developed than there were in formation from which typhoons did not develop. Figures 6, references 27: 18 Russian, 9 Western.

UDC 551.463.5:551.464:528.8

Reconstruction of Trace Concentrations in Eutrophic Waters of the Baltic Sea From Ascending Radiation Spectrum

18660138c Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 89 (manuscript submitted 12 Oct 87) pp 27-33

[Article by V. N. Pelevin and V. L. Solomakha, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Moscow]

[Abstract] The possibility of using remote methods to study concentrations of foreign matter in the heavily polluted waters of Parnu Bay, Parnu River, and the Gulf of Riga is examined. In determining individual pollution components from the spectrum of the emissions ascending from the sea, the authors analyze the spectral reflectance of the sea surface. They design an optical model and calculations for the remote determination of the scattering and absorbing light of the matter, and they conclude that reconstruction of the concentrations in eutropic waters is possible only within strict constraints for accuracy of measurements of the spectral reflectance of the sea. Such accuracy can be achieved in clear weather, when the sky is cloudless and the sun is at an angle of no less than 30°. The presence of clouds requires the use of photometers placed beneath the sea surface, to preclude the need to allow for the Fresnel reflection of the sky by the water surface. A graph of the spectral dependences of the reflectance of the sea measured in the Baltic in 1986 points to the strong link between the shape of the reflectance curve and the region of measurement, i.e., the concentration of foreign matter. The authors indicate that Soviet MSU-M and MSU-SK scanner systems, with spectral channels of 0.5-0.6, 0.6-0.7, and 0.7-0.8 micron in the visible range, can be used for such analysis. Figures 3, references 16: 12 Russian, 4 Western.

UDC 551.521:629.78

Some Features of the Variability of Outgoing Long-Wave Radiation Over the Tropical Atlantic

18660138d Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 89 (manuscript submitted 8 Jul 87) pp 34-44

[Article by G. S. Dvoryaninov and Ye. M. Lemenshko, Marine Hydrophysical Institute, UkSSR Academy of Sciences, Sevastopol]

[Abstract] Satellite data is used to study certain features of the intraannual and interannual variability of outgo-

ing long-wave radiation over the Atlantic Ocean that is caused by shifting energy-active zones. The authors use a study of the space-time variations of the outgoing long-wave radiation field to delineate regions of active thermal interaction between ocean and atmosphere, as well as regions with lowered ocean-atmosphere interaction. The base data of the study consist of average monthly values for outgoing long-wave radiation derived by NOAA satellites from June 1974 through February 1978 (with a spatial resolution of 2.5°) and by Nimbus-7 from November 1978 through October 1983. Calculations indicate that the zones of anomalous variability are of a dipole nature, with centers in the regions of the western coast of Africa and the northeastern shores of South America. The zones fluctuate with a period of about 2 months, show evidence of migration, and envelop virtually the entire tropical region of the northern hemisphere. The time-based variability of the outgoing long-wave radiation anomalies that are integral in terms of space points to a biannual cycle and links the anomalies with El Nino. Figures 5, references 8: 4 Russian, 4 Western.

UDC 528.831

Optimization of Parameters of Systems for Radiothermal Mapping of the Earth's Surface
18660138e Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 89 (manuscript submitted 20 Jul 87) pp 77-86

[Article by A. P. Pichugin and S. A. Shilo, Institute of Radiophysics and Electronics, UkSSR Academy of Sciences, Kharkov]

[Abstract] A great deal has been written about a promising direction taken by remote studies of the environment—the use of HF-radiometry based on the determination of the parameters of natural object from their radiothermal reradiation. Most of the work in this area, however, has been limited to the experimental stage, one reason being the relatively low information content of the experimental systems and their low spatial resolution. Because improving the quality of the information derived with radiometric mapping systems is often done at the expense of other parameters, the authors assert the importance of using a systems approach in developing radiometric assemblies and their components and in optimizing their parameters, as well as the neeed to develop systems of quantitative evaluation that enable a comparative analysis of technical solutions. They introduce groups of equations that are used to assess radiothermal systems as data links, thereby enabling analysis of the systems on the basis of criteria that are applicable to traditional systems of data transfer. Viewing the radiothermal systems as data links also makes it possible to delineate the sequence of basic components that distort the initial signal spectrum as a result of filtration and the effects of noise. The technique advanced by the authors assesses the effect that parameters such as receiving antenna aperture, system noise temperature, and low-frequency filter characteristics have on information content. Figures 6, references 10: 8 Russian, 2 Western.

UDC 528.8.044.4

Highly Sensitive HF Radiometer-Scatterometer for Remote Sensing of the Earth's Surface
18660138f Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 89 (manuscript submitted 12 Nov 87) pp 87-93

[Article by N. N. Borsin, V. B. Venslavskiy, A. A. Glotov, V. G. Mirovskiy, L. A. Smirnova, A. Sh. Shamba, and V. S. Etkin, Moscow State Pedogogical Institute imeni V. I. Lenin]

[Abstract] The authors report the results of their development of a radiometer-scatterometer system that uses a degenerate parametric amplifier at the input of the receiver. A special feature of the amplifier consists of the frequency modulation of the pumping signal that forms when the sensing signal frequency is doubled. The radiometer-scatterometer is designed to make simultaneous measurements of the relative magnitude of the effective scattering area and the radiobrightness temperature of the Earth's surface at λ = 1.5 cm. The instrument includes a receiving antenna and a transmitting antenna, a common HF input tract, separate radiometer and scatterometer channels behind the mixer, a transmitter, and systems for low-frequency processing of signals and for control of HF elements, a thermostat unit, and a power source. The radiometer is a superheterodyne receiver that uses modulation to extract the signal. The scatterometer is a special continuous-emission radar unit with tonal frequency modulation of the signal and receiver extraction of the second harmonic of the modulation frequency. The authors present results of the use of the system in the first half of October 1985 for sensing the ocean surface in the Pacific. Figures 3, references 9: 8 Russian, 1 Western.

UDC 528.727

Radiometric Correction of Aerospace Images
18660138g Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 89 (manuscript submitted 4 Oct 86; final draft 23 Oct 87) pp 87-93

[Article by A. S. Barykin, All-Union Scientific Research Center AIUS-Agroresursy, Moscow]

[Abstract] The technique advanced by the author for radiometric correction of terrain images by means of approximation allows for the specifics of the thematic tasks being addresses and assumes the use of a space-based multizonal scanning radiometer as the imaging system. Unlike the radiation correction techniques, which solve boundary problems for equations radiation transport in the atmosphere, the radiometric technique

requires virtually no information on the physical parameters of the atmosphere and does not reduce the information content of the images by comparison with the ratios method. Good results with the radiometric approximation technique require the following: the number of elements of the digital matrix of the image must exceed 10^6 with a line length of 256 elements; similar objects must be distributed uniformly on the image; the terrain must be orthotropic or must have one type of non-orthotropicity. Processing a single frame 512 X 512 elements in size in six channels on a minicomputer takes no more than 4.5 minutes. Figures 5, references 5: 3 Russian, 2 Western.

UDC 528.72(202):551.51

Methodological Aspects of the Automation of the Calibration and Processing of Satellite-Derived HF Radiometer Data

18660138h Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 89 (manuscript submitted 4 Nov 86) pp 87-93

[Article by A. B. Akvilonova, M. S. Krylova, B. G. Kutuza, B. Z. Petrenko, V. P. Savorskiy, and M. T. Smirnov, Institute of Radioengineering and Electronics, USSR Academy of Sciences, Moscow]

[Abstract] A procedure is proposed for automating the processing of multichannel HF radiometer satellite data of along-track measurements. The procedure, developed at the Institute of Radioengineering and Electronics, focuses on calibrating experimental data and assessing output parameters HF radiometers. The procedure combines the experience garnered in the processing and analysis of data derived with Cosmos series satellites as well as with Interkosmos-20 and Interkosmos-21. The procedure consists of three stages: on-line analysis, primary processing, and thematic, or secondary, processing. The purpose of the on-line analysis is to check the efficiency of the HF radiometer equipment and to evaluate the quality of the incoming information. A block diagram of this stage is provided (as are block diagrams for the other stages). The radiometer scales are calibrated in the primary processing stage; relative calibration is used. The final stage of the procedure includes determination of the geophysical parameters of the ocean-atmosphere system and the characteristics of the ice cover of the Arctic and Anarctica, as well as derivation of fields of emission characteristics at various wavelengths and polarizations and fields of hydrometeorological parameters of the atmosphere and ocean. The procedure is implemented in FORTRAN and can be run on minicomputers. Figures 6, references 22: 18 Russian, 4 Western.

UDC 528.7:528.8

Computer Synthesis of Textures Simulating Earth's Surface

18660138i Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 89 (manuscript submitted 8 Jan 88) pp 115-121

[Article by G. A. Andreyev, A. A. Potapov, T. V. Galkina, A. I. Kolesnikov, T. I. Orlova, Ya. L. Khlyavich, Institute of Radioengineering and Electronics, USSR Academy of Sciences, Moscow; Voronezh State University]

[Abstract] In examining a linear autoregression model for synthesizing texture fields that simulate ground cover, the authors provide experimental data pertaining to the determination of the statistical characteristics of optical and radio images and perform computer synthesis of several texture fields. The authors used a YeS-1060 computer to synthesize a marine texture, a deciduous forest texture, a corn field texture, and a sand texture. The synthesized textures were compared against actual textures by (a) comparing first-order histograms, mean values, and brightness dispersions and (b) using a correlation algorithm to determine the similarity between a synthesized plot and actual plots. Autoregression synthesis typically needs few given parameters and does not take much machine time. Figures 4, references 11: 10 Russian, 1 Western.

UDC 061:[528.77:631.1:629.78]

First All-Union Meeting 'Aerospace Methods in Soil Science and Their Use in Agriculture' (Moscow, October 1987)

18660138j Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 1, Jan-Feb 89 pp 122-123

[Article by V. L. Andronikov, G. V. Dobrovolskiy, and V. A. Obukhova]

[Abstract] The October 1987 meeting "Aerospace Methods in Soil Science and Their Use in Agriculture" was attended by 250 individuals from 55 Soviet scientific, educational, and industrial organizations. In a problem-defining report, V. L. Andronikov and G. V. Dobrovolskiy touched on the principal issues of space-based soil science: spectrometry of soils, crop fields, meadows, and pastures; the use of aerospace photos for determining rate of change, for predicting changes in the soil-vegetation cover and the effectiveness of the use of various farming systems, and for comparing soil maps. A number of reports examined the use of spectrometric data for studying soil and vegetation forms, experimental models of spectrometric gear were demonstrated, and data were presented on the use of spectrometric indices involving soils, rock, and vegetation for the purpose of setting up reliable system for monitoring changes in natural resources. Other reports were devoted to matters of soil interpretation and cartography based on aerial and

space-derived images. Various aspects of the use of aerospace photos were examined in the context of a comparison of soil maps of differing scales and for studying vrious natural regions of the country. The meeting's participants demonstrated the broad front of work that is being done in the use of aerospace data for monitoring soil resources, improving the fertility of soils and protecting them, increasing the yield of agricultural croplands, and enhancing the productivity of meadows and pastures.

USSR and International Cooperation in Space

18660110 Moscow NOVOYE V ZHIZNI, NAUKE, TEKHNIKE: SERIYA KOSMONAVTIKA, ASTRONOMIYA in Russian No 12, Dec 88 pp 32-47

[Article by S. A. Nikitin: "USSR: International Cooperation in Space]

[Text] As 1988 comes to a close, this cooperation was successfully pursued in the framework of the multilateral program Intercosmos with nine socialist countries (Bulgaria, Hungary, Vietnam, East Germany, the Republic of Cuba, Mongolia, Poland, Rumania, Czechoslovakia), and on a bilateral basis with Austria, Great Britain, India, the United States, Finland, France, West Germany, Switzerland, Sweden and other nations, as well as the European Space Agency. Joint projects in the Intercosmos program are being carried out in the area of space physics (including space materials science), space meteorology, communications, space biology and medicine, as well as remote sensing of the Earth for purposes of studying its natural resources. Joint projects in space on a bilateral basis with the aforementioned countries have covered practically all main areas of cosmonautics.

In 1988 the main events in the international cooperation of the USSR in space were: international experiments aboard the Mir orbital scientific research complex, flights of Soviet-Bulgarian and Soviet-Afghan international crews, the launching of two unmanned interplanetary Phobos vehicles, and the launching of the Indian satellite IRS-1A on a commercial basis. By the end of 1988, there are plans to carry out a second Soviet-French manned flight expected to last around 30 days (with a scheduled spacewalk by the French cosmonaut) and to launch an artificial Earth within the Aktivnyy project.

On 1 Dec 1987, USSR Minister of Foreign Affairs E. A. Shevardnadze and Australian Minister of Foreign Affairs and Foreign Trade U. Heyden signed an agreement in Moscow between the governments of the USSR and Australia for cooperation in the area of the study and utilization of outer space for peaceful purposes. The agreement calls for joint research and experiments in such fields as solar-terrestrial physics, space astronomy, high-energy astrophysics, space materials science, and space biology and medicine.

During the visit of U.S. President Reagan to Moscow, USSR Minister of Foreign Affairs E. A. Shevardnadze and U.S. Secretary of State G. Schultz exchanged notes between the USSR foreign affairs ministry and the U.S. embassy in Moscow on 31 May 1988, regarding an expansion of the list of areas of cooperation stipulated by the 15 April 1987 intergovernmental Agreement for Cooperation in the Study and Utilization of Outer Space for Peaceful Purposes.

In December 1987, under instructions from the USSR Glavkosmos, Litsenzintorg concluded an agreement with the Kaiser Trade Co. (West Germany) involving three research experiments to be carried out aboard Soviet Foton spacecraft in 1989-1992. This is the first commercial agreement concluded by Soviet organizations with foreign partners in the area of space technology—the production of substances that have unique properties and cannot be produced under terrestrial conditions. The results of research on semiconductor materials, alloys, and protein structures may be extremely valuable to the development of future technologies, including biotechnology and genetic engineering.

Kaiser Trade will build the apparatus and deliver it to the Soviet Union, where it will be installed on the Fotons, which are designed to conduct production and other experiments under conditions of microgravity and to be placed in orbit by Soyuz-type booster rockets.

As for the prospects of international cooperation of the USSR in space—in both the near and the long term—we can say the following.

There is a government-level arrangement between the USSR and Austria for a joint flight of Soviet and Austrian cosmonauts, to be conducted in the early 1990s. Preparations are continuing for the launch of satellites in the Apex and Interbol projects. At a press conference at the Baykonur space center, V. M. Kovtunenko—chief designer of the Phobos vehicles, corresponding member of the USSR Academy of Sciences, and member of the International Scientific Council for the Phobos Project—reported that the next steps in the exploration of Mars will be to dispatch Martian rovers to the planet in 1994 and 1996 and to bring samples of the Martian soil back to earth in 1998. The development of the science program for these projects and the creation of the scientific apparatus for the vehicles are expected to be done on the basis of broad-based international cooperation. At that same press conference, A. I. Dunayev, chief of the USSR Glavkosmos, stated that a manned flight to Mars could be achieved in 2015-2017. In the opinion of Soviet and American specialists, such grandiose expedition can be accomplished only on the basis of international collaboration. In the estimation of American specialists, the creation of such spacecraft would take around 50 billion dollars; Soviet specialists think it would require 25-30 billion rubles.

International experiments aboard the Mir orbital complex. The science program of the crew of the long-term expedition aboard the Mir station—cosmonauts V. G. Titov and M. Kh. Manarov—included a good many international experiments.

The international program of investigations in extra-atmospheric astronomy continued with the apparatus of the astrophysical module Kvant. The module docked

with Mir in April 1987. For studies in the area of extra-atmospheric astronomy, it has the following:

- the Rentgen orbital observatory—an instrument package created by scientists of the Soviet Union, Great Britain, the Netherlands, West Germany and the European Space Agency and designed to investigate the emissions of x-ray sources in the sky, as well as the spectrum of such sources
- the Glazar ultraviolet space telescope, created by scientists of the Soviet Union (Byurakan Astrophysical Observatory) with participation by specialists of Switzerland and designed to obtain photographs of sectors of the sky in the wavelength range of 120-130 nm.

In 1987 the crew of the previous long-term expedition of Mir—cosmonauts Yu. V. Romanenko and A. I. Laveykin (and A. P. Aleksandrov)—obtained interesting scientific results with the Kvant instruments. First and foremost, there were the investigations of the supernova in the Large Magellanic Cloud, which flashed in visible and ultraviolet rays on 23 Feb 1987 (it has come to be known as supernova 1987A). It was, in fact, with the registration of the x-radiation from this supernova on 9 June 1987 that the cosmonauts began the long-term international program of astrophysical investigations with the Rentgen observatory.

On 10 Aug 1987, the Rentgen observatory picked up x-rays with an unusually hard spectrum from the region of the supernova in the Large Magellanic Cloud, and after that the supernova became the principal target of observation of the space observatory. The emissions from the supernova were registered in nine wavelength bands, and in one of them, the discovery was independently confirmed by the Japanese x-ray satellite Ginga (Milky Way), launched on 5 Feb 1987.

After the famous Kepler supernova of 1604, this was the first object of its type that could be observed in visible light with the naked eye. The registration of the x-ray emissions from the supernova in the Large Magellanic Cloud was delayed by half a year. It took that much time for the x-rays to pierce the massive supernova shell (around 15 solar masses), flying apart at speed of 1000 km/s.

The discovery of the hard x-radiation confirms the results of calculations on the nuclear reactions deep within stars just prior to their demise. Preliminary analysis shows that the observed flux is consistent with the synthesis of radioactive nickel (around 1/10 the mass of the sun), which is hurled outward by the explosion and decays within the massive dispersing shell into radioactive cobalt, and then iron.

The gamma quanta emitted upon decay lose their energy when, in moving through the massive shell, they collide with electrons, and they reach us in the form of x-rays. Over the month of observations, the flux of x-rays increased by 20%. The rate of buildup of the flux and its spectrum provide information on the mass, speed of dispersion, and geometry of the shell ejected by the explosion. This is a major discovery, the first time astronomers have observed such radiation.

It should be pointed out that scientists "saw" seven sources in the galaxy of the Large Magellanic Cloud on the x-ray photographs. This was made possible by the high degree of stabilization of the Mir orbital science complex. During the observation session, the huge complex, with mass of around 55 tons, "holds" its aim with an accuracy of one minute of arc. That makes Kvant a unique observatory for astrophysical investigations.

How did events develop later? In the second half of September and in early October 1987, calibration and alignment of the apparatus of the Rentgen orbital observatory were performed. For this, its telescopes were aimed at the Crab Nebula. After that, the international observatory continued its studies of the supernova in the Large Magellanic Cloud. The task of the subsequent observations was to find the neutron star or "black hole" lying behind the shell and formed as a result of the death of the original stellar object.

In the second half of October 1987, a sharp change was registered in the spectrum of x-rays of the supernova. The data indicated a rapid brightening of the star's shell.

The studies of supernova 1987A in the Large Magellanic Cloud were continued in 1988 by cosmonauts V. G. Titov and M. Kh. Manarov. In January and February, new information was obtained as to the evolution of the emission spectrum of the object. Results of the processing of the obtained data showed that the flux of hard x-radiation from the supernova in the last two months was higher by a factor of more than 1.5 than that registered in period of August-October 1987. The growth of the radiation flux and the evolution of its spectrum indicate, specifically, a further brightening of the supernova shell and the fact that the radioactive cobalt is not concentrated at the center of the shell, but is distributed over a large volume.

Hence, we may now draw three major conclusions from the results of registration of the emissions of supernova 1987A and from its investigation:

For the first time, it was possible to observe a star prior to its explosion, and therefore the astronomers know what kind it was. And whereas it was earlier established that a burst can be expected in the red giant phase, on this occasion—the only known instance in history—it was a blue supergiant that exploded.

The registration of the supernova x-radiation by the equipment of the Kvant module, as well as the instruments of the Japanese satellite Ginga, enable a number of fundamental assertions as to the nature of the nuclear reactions deep within a star prior to its destruction and as to the ensuing events.

The gamma radiation from the supernova that took as long as August 1987 to reach Earth contained lines of radioactive cobalt-56 with a half-life of around 78 days. This means that cobalt is created during the course of the

explosion itself: otherwise the greater part of it would have decayed to form other elements. This observation is the first direct confirmation of the hypothesis that heavy elements are created in the incredibly high temperatures (500 billion degrees) and pressures that come about in the explosion of a supernova.

Besides the supernova, the telescopes of the Rentgen observatory observed the x-ray sources Cygnus X-1 and Cygnus X-3 and the x-ray pulsar Hercules X-1 in the Large Magellanic Cloud.

Interesting results were obtained from registration of the emissions from a new x-ray source, which exploded on 26 April 1988 in the Vulpecula constellation. The telescopes of the Rentgen observatory also recorded (in addition to a soft component) the presence of hard x-rays corresponding to temperatures above a billion degrees. The hard radiation component of this source accounts for about a third of the energy released. This source in the Vulpecula constellation has not yet been recorded in the optical wavelength range. It should also be emphasized that this is the first registration of such temperatures for this class of star in the history of astrophysical studies.

The cosmonauts also continued studies with the Glazar UV telescope. In particular, surveys were made of individual sections of the celestial sphere near Alpha Aquila and Alpha Lupus, and of individual regions in the constellations Corvus, Virgo, Leo, Ursa Major, Corona Borealis, Carina, Ursa Minor, Orion, Eridanus, Columba, and Puppis.

The cosmonauts are continuing the investigations with the scientific apparatus of the Kvant astrophysical module.

V. G. Titov and M. Kh. Manarov also performed other international experiments: in particular, the aerospace experiment Caribe-Intercosmos 88 (see the previous article.)

In August 1988, the cosmonauts took part in studies within the program of another international aerospace experiment, Tien Shan-Intercosmos 88. The experiment was carried out for geological purposes, in particular, to upgrade the remote means and methods of studying seismically active regions of earth. Using stationary cameras and spectrometric equipment, the crew made several series of surveys of individual portions of the territory of the Soviet Union east of the city of Dushanbe and in the region of the Toktogul reservoir.

In keeping with the arrangement between the Soviet Union and Australia, an experiment was carried out with the Aynur biotechnology unit for the purpose of producing a single crystal of a flu virus antigen in microgravity for subsequent investigations of its three-dimensional structure and properties.

Other international experiments aboard the Mir scientific research complex were also carried out.

Launching of the Indian satellite IRS-1A. On 17 March 1988, at 09:43 Moscow time, the Indian satellite IRS-1A was launched from the Baykonur space center in the Soviet Union. The Vostok booster rocket placed the satellite in a sun-synchronous polar orbit with an altitude of 917 km at apogee and 863 km at perigee, an inclination of 99.01°, and an orbital period of 102.7 min.

The satellite weighs 974 kg and is designed to use electrooptic equipment for remote sensing of the Earth and production of on-line information for use in studying the natural resources of India.

The work of preparing and implementing the launch of the Indian satellite was done by the USSR Glavkosmos in keeping with a commercial agreement concluded between the Litsenzintorg foreign trade association and the Indian Space Research Organization (ISRO). This was the first commercial launch in our country (ISRO paid the Soviet side $7 million for the booster rocket and launch support services.)

The satellite is equipped with three television cameras, working in three visible ranges and one near-infrared range. One camera scans a swath of the Earth's surface 140 km wide with a local resolution of 70 m; the other two a survey zone 80 km wide with a resolution of 36 m.

A sun-synchronous orbit was selected for the surveys, and the launch time was chosen to enable a survey of the Indian territory during the morning hours that are best-suited for this purpose. The survey of each given sector of the Earth's surface is repeated every 22 h.

The electric power for the satellite is provided by solar batteries (545 W power at the end of the scheduled operating period of 3 years).

During the initial stage, the IRS-1A satellite was controlled by the Soviet Medvezhi ozera [Bear Lakes] tracking station on the outskirts of Moscow and the Indian control center at Bangalore. Each day, the information from the station is received by the station at Hyderabad, where a complex of equipment for processing the information received has also been built. After processing, the information is transmitted to the users for purposes of mineral prospecting and study of crop, forest, ground cover, and water resource conditions.

USSR-Bulgaria: second manned flight. The space flight of the second Soviet-Bulgarian international crew took place 7-17 June 1988.[1] The crew, which took off aboard the Soyuz TM-5 spacecraft on 7 June at 18:03 Moscow time, was made up of Commander A. Ya. Solovyev, Flight Engineer and USSR Cosmonaut-Aviator V. P. Savinykh, and cosmonaut-scientist A. P. Aleksandrov, a

citizen of the People's Republic of Bulgaria.[2] The flight took place in keeping with the arrangement between the governments of the USSR and Bulgaria.

Project Shipka is what our Bulgarian friends call the work involving the preparations and implementation of the second joint space flight. Shipka is the symbol of the military comradeship of Russian and Bulgarian soldiers, which led 110 years ago to the liberation of Bulgaria from the Osman yoke. Today, Shipka is a fraternal association of the scientists of both countries for peaceful conquest of space for the good of our peoples and the good of all mankind.

Professor Boris Bonev, director of the Space Research Institute of the Bulgarian Academy of Sciences, stated at a press conference just prior to the launch that project Shipka cost 7 million Lv. The program includes scientific and technical experiments that are not only aimed at acquiring new knowledge which will lay the scientific groundwork for the future, but also possess great economic importance already today.

Nine years ago, for the flight of their first cosmonaut, Bulgarian specialists created three instruments for conducting research aboard the orbital station. There is three times as much equipment today. The number of experiments has grown by a factor of 2.5, reaching 42 titles. Qualitative changes have also taken place in the conduct of the research. The equipment of today makes it possible to perform on-line analysis of the findings right on board, whereas previously the cosmonauts were forced to work practically "in the dark," which didn't allow the necessary corrections to be be made in the observational program. All of this substantially expands the range of research, makes it more in-depth, and, consequently, increases its value.

The total weight of the Bulgarian apparatus with all attachments, packaging, and miscellaneous accessories exceeds 200 kg. Of course, such mass could not be lifted on the Soyuz TM-5, and, because of its size, there simply wouldn't be any place to put it. Therefore, nearly all the equipment for the Soviet-Bulgarian experiments was taken to Mir in advance, aboard the Progress-36 cargo ship.[3]

For the flight of their first cosmonaut, the Bulgarian specialists created the Spektr-15 spectrophotometer. The instrument was delivered to the Salyut-6 station, where the Soviet and international crews worked with it successfully. An updated version of this instrument was used aboard Salyut-7. And now, under the guidance of Professor D. Mishev, the new instrument Spektr-256 has been developed at the Space Research Institute of the Bulgarian Academy of Sciences. The number 256 in the title of the instrument means that it is able to register the spectral characteristics of the Earth's surface not in 15 wavelength bands, like the previous Spektrs, but in 256 bands of the visible and infrared ranges. And if we consider that each band can register its own characteristic signature of the observed object, the increased information capacity of the new instrument is readily appreciated. A microcomputer with floppy disk memory is used to record the acquired information. During spectrometric survey of the earth's surface and atmosphere with the Spektr-256, the instrument is capable of simultaneously performing photo tie-ins to subjects of the investigated sectors of terrain, objects, or atmosphere.

The remote Earth sensing program is called Georesurs and includes 18 experiments. Among them is a study of specially selected test regions within Bulgaria and the Soviet Union, where aircraft and ground observations are being carried out simultaneously. The investigation covers not only the land, but also the shelf, and the Black Sea itself, as well as the earth's atmosphere and its pollution as a result of human activity and natural phenomena. The experiments are being conducted with the multichannel spectrometer Spektr-256, the Soviet stationary wide-format camera KATE-140, and handheld cameras. Spektr-256 will be used also to investigate the change in spectral and reflecting characteristics of the portholes of the orbital complex as affect by space flight factors. This is necessary in order to make allowance for errors introduced by the glass of the portholes in the observations of Earth and the starry sky.

The work of the Bulgarian scientists in the area of remote Earth sensing is world-renowned. And it is no accident that the leader of the remote sensing section at the International Astronautics Congress, held in Brighton (England) in 1987, was Professor D. Mishev.

The Bulgarian specialists are using the data acquired by satellite and aircraft for purposes of geology, geomorphology, soil science, geodesy, cartography, ecology and other fields of science and the national economy. At a number of institutes in Bulgaria, analysis of space television images has been adopted as a method for solving on scientific and practical problems. Space survey has been used to establish linear cleavages and ring structures, which are indirect indicators of the presence of various minerals. Two seismic maps have been compiled with the use of space information: a map of the territory of Bulgaria on a scale of 1:1,000,000 and a map of the northeastern section of the republic on a 1:500,000 scale. Interpretation of the space images obtained with the Salyut-6 orbital station made it possible to construct a tectonic map of Bulgaria. Structural identification of the Balkan peninsula with data from the Meteor satellites has also been done.

Bulgarian scientists also have considerable accomplishments in the field of space physics. Their most monumental project was Bolgariya 1300, carried out in 1981 with the Soviet Meteor-Priroda satellite (Intercosmos-Bolgariya 1300). Bulgaria is an indispensable participant in such colossal international projects as Vega, Phobos, and Interbol.

Using existing experience, the Bulgarian specialists created for the Shipka project unique instruments that meet the most modern requirements. The astrophysical instrument complex Rozhen was developed jointly by the University of Sofia and the Space Research Institute of the Bulgarian Academy of Sciences. Using a long-focus lens, the Rozhen complex receives the image of a section of the nighttime sky and registers it not on photosensitive material, but on a CCD matrix, where this image is converted into electrical signals and encoded in digital form. The data collection and recording unit is designed on the basis of a personal computer, which is used to process the acquired data and control all operating modes of the complex. A catalog of 260,000 stars has been entered into the computer memory. On the display screen, the operator sees a picture of that portion of the sky selected for investigation. At the same time, that same image is sent by telemetry channels to Earth. The pace of the experiment is automatically controlled, but the operator always has the opportunity to make necessary corrections. The Rozhen complex is designed to measure the optical emissions of various astronomical objects: stars, galaxies, nebulae, and so forth. It can also be synchronized with the international orbiting Rentgen observatory, which is installed in the Kvant module.

The Parallaks-Zagorka electron-optic spectrometer is a special adapter placed on the lens of the Rozhen astrophysical complex. A system of interference filters makes it possible to single out narrow spectral bands, whose brightness is then magnified a thousandfold. In this way, it is easy to study the polar lights and other luminous phenomena in the upper atmosphere of Earth.

Yet another instrument—the Terma pulsed photometer—is designed for investigations with high spatial-temporal resolution of the distributions of intensity of natural optical emissions in the Earth's atmosphere and for observations of the atmospheric glow near the orbital complex and of the stars setting beyond the atmosphere.

Space materials science is represented by three experiments in project Shipka: Kliment-Rubidiy, VOAL, and Struktura. All of these are performed with the Kristallizator ChSK-1 multifunctional electric heating unit, made in Czechoslovakia. The goal of the Kliment-Rubidiy experiment is the production of single crystals of $RbAg_4I_5$ in terrestrial and space conditions and subsequent comparative investigation of the resulting specimens. These monocrystals are interesting for the fact that they possess high ionic conductivity at room temperature and can be used to construct small batteries and condensers of very high capacity, as well as high-precision temperature sensors.

Production of composite alloys of tungsten-aluminum with varying content of the tungsten component was performed in the VOAL experiment. The Struktura experiment was devoted to investigation of the influence of iron admixture on the eutectic structure of aluminum-copper alloy.

Comprehensive investigation of the cosmonaut's efficiency during the initial phases of adaptation to space flight conditions was the primary direction of the biomedical program of project Shipka. This included study of the operator activity of the cosmonaut, the physiological and psychological reactions of his body, and the condition of the analyzer systems. Furthermore, the program also entailed radiobiological studies aimed at upgrading the means and methods of radiation monitoring aboard the orbital complex. To implement this program in Bulgaria according to the requirements specifications agreed upon with our specialists, a whole complex of special apparatus was developed. The core component is the Zora microprocessor system with two electromyogram amplifiers, a set of electrodes for registration of the biopotentials of the muscles, and various attachments for physical stress. The Zora system also makes it possible to simplify operator training and work. The necessary instructions have been entered into its memory and can always be called up on screen. The system is capable of automatic collection and analysis of materials during the course of the experiments. The obtained information is stored in the memory and sent to Earth during the communications sessions by telemetry channels, or is brought back on diskette.

In the creation of the Pleven-87 instrument, the basic philosophy was to simulate the essential elements of operator activity. The instrument is built on a microprocessor system and consists of three main units: a control unit, a stimulus field, and a control panel. The control unit performs all the arithmetic and logic operations. It accomplishes arithmetic computations, measures time intervals, carries out self-testing of the instrument, and maintains communications with the external devices. On the stimulus field, light stimuli are presented during the investigation. The control panel is designed to guide the operation of the instrument. Its function keyboard controls the operating modes, while the number keyboard is used to enter test parameters and send responses to the stimuli during the examination. Information as to the current operating mode of the instrument, the parameters of the test under way, or the results of the test are shown on an information board. The data obtained during the experiment are sent to the Zora system.

The job efficiency of the cosmonaut largely depends on his functional condition, which is a function of the proper complement of sleep and relaxation. Information on sleep in space flight conditions is still inadequate, especially during the initial period of adaptation to weightlessness. In order to obtain such data by means of registration of electrophysiological indicators, the Bulgarian specialists created the Son-3 self-contained system.

To investigate the radiation environment in the orbital complex, obtain data for evaluating the degree of influence of ionizing radiations on the body, and develop protective measures, the Bulgarian specialists created the

highly sensitive Lyulin radiometer and the Doza-B set, which includes detectors and biological materials situated at various points in the living compartments.

On 17 June 1988, after completing the program of joint work on board the Mir scientific research complex, the international crew returned to Earth: the descent module of the Soyuz TM-4 ship with cosmonauts A. Ya. Solovyev, V. P. Savinykh and A. P. Aleksandrov touched down 202 km southeast of Dzhezkazgan. The length of the flight of the second Soviet-Bulgarian international crew was 9 days 20 hours 10 minutes.

Launching of the Phobos unmanned interplanetary vehicles. On 7 and 12 July 1988, the unmanned interplanetary vehicles Phobos-1 and Phobos-2 were launched in the Soviet Union. The launches were effected by four-stage Proton booster rockets in accordance with the international project Phobos for comprehensive exploration of the planet Mars, its moon Phobos, the sun, and interplanetary space.

The Phobos vehicles became the first representatives of a new generation of Soviet scientific spacecraft created at the G. N. Babakin Scientific Experimental Research Center of the USSR Glavkosmos. These vehicles are capable of handling difficult multiple-goal missions involving the study of various objects in the solar system. For example, the mass of Phobos-1 is 6220 kg.

Participating with Soviet specialists in the development of the science program of project Phobos and in the creation of the complex of scientific apparatus and equipment were scientists and specialists from Austria, Bulgaria, Hungary, East Germany, Ireland, Poland, Finland, France, West Germany, Czechoslovakia, Switzerland, Sweden, the United States and the European Space Agency. Aboard each vehicle is an instrument package weighing around 300 kg (not counting the landing probes). The science director of the project is R. Z. Sagdeyev, director of the Space Research Institute of the USSR Academy of Sciences.

The flight to Mars will take around 200 days: in late January 1989, the vehicles will reach the environs of the planet and perform remote investigations of its surface and atmosphere from areocentric orbits.

In April-May 1989, the vehicles are scheduled fly at a distance of several tens of meters above the surface of Phobos for the purpose of performing a comprehensive study of the Martian moon. Plans call for the study during this period of the elemental and isotopic composition of the soil of the celestial body by means of laser and ionic probing, the first such investigation in the history of planetary experiments.

As the vehicles reach their closest points to Phobos, the autonomous landing probes will separate to perform scientific experiments and television survey on the surface of the Martian moon. They will be tracked by the Earth-based radiotelescopes of the USSR and United States and by the international radioastronomical network. The main difference between Phobos-1 and Phobos-2 is that the former has a landing probe (long-term autonomous station) that will perform investigations only at the landing site; the probe of the other vehicle can move about the surface of the Martian moon in hops. Thus, it will ascertain the characteristics of the surface of Phobos at various points (after one measurement cycle, the repulsion device makes the probe jump a distance of 20 m; the number of cycles is as many as 10.)

The science program of the project also includes lengthy investigations of the sun, the interplanetary medium, near-Mars space, and gamma bursts. The total duration of the expedition is almost a year and a half (460 days).

In keeping with the flight program, corrections in the trajectories of motion of the vehicles were made on 16 and 21 July. Measurements made after the maneuvers revealed that the Phobos vehicles were continuing their flight on near-nominal trajectories.

Sagdeyev Discusses Space Missions, Policy, Mars Plans

18660073a Moscow PRIRODA in Russian
No 1, Jan 89 pp 33-46

[Interview by PRIRODA correspondent with Roald Zinnurovich Sagdeyev, academician, specialist in the field of plasma physics and space research, chairman of the Soviet Scientists' Peace Committee, Hero of Socialist Labor, recipient of the Lenin and State prizes, member of the U.S. National Academy of Sciences, the Swedish Royal Academy, the Max Planck Society and a number of other academies, under the rubric "The Organization of Science. Space Research": "Let Us Not Put Ourselves in the Position of the Junior Partner!"; first paragraph, given in boldface as printed, is PRIRODA introduction]

[Text] **Space research, despite its relative youth (the 30th anniversary of the beginning of the Space Age was observed not that long ago), has become a well-established part of our lives. We have become accustomed to regular launches of manned craft and unmanned cargo craft into near-earth orbits and no longer remember very well how many people make up the cosmonaut contingent in our country, not to mention those in the USA. It is true that we continue to be enraptured as we view the magnificent photographs on which have been imprinted the Earth or, for example, the giant planets Uranus, Jupiter or Saturn. But this is a glance from the side. But what is actually going on in this field of science and technology whose actual state of affairs we have long known less than we would have liked to have known? What problems are troubling the specialists who have devoted themselves to cosmonautics? Academician R. Z. Sagdeyev, who headed up the USSR Academy of Sciences's Space Research**

Institute for more than 15 years, shares his own thoughts in this connection in an interview with our magazine's correspondent, N. D. Morozovaya.

[Correspondent] For the two great space powers—the USSR and the USA—the year 1992 will be rich in major historic events: it represents the 500th Anniversary of the discovery of America, the 75th Anniversary of the Great October Socialist Revolution and the 35th Anniversary of the beginning of the Space Age. Is it true that, at the suggestion of these two countries, it has been proposed that the year 1992 be declared World Space Year?

[Sagdeyev] In fact, such an idea is being discussed now in the various international unions and, evidently, the ICSU—the International Council of Scientific Unions—is supporting it. (I would remind you that all scientific unions belong to the ICSU, including our COSPAR—the Committee on Space Research). Everyone recalls what a colossal success the International Geophysical Year was (1957-1958), during which the earth's very first artificial satellite was launched. This year brought together, in an unusual manner, scientists from many countries, and the international scientific community welcomed the news about the launching of the Soviet satellite with enormous enthusiasm. And now, 30 years after that event, the very same ideas are guiding the scientists who are proposing this time that an International Space Year now be declared. If such a resolution is adopted, I am certain that UNESCO will also support it.

It is difficult to overestimate the significance of so important a measure; it will produce an occasion for exchanging views about what has been done in space in the past and what needs to be done in the future. Above all, this should strengthen international cooperation. Additionally, it is now very important that an active promotional campaign be conducted among the broad masses regarding the achievements of cosmonautics and space science, because, on the one hand, space science and technology can play an enormous role in solving many contemporary global problems, and I have in mind, first and foremost, ecological and economic problems, not to mention space science itself, which is experiencing a period of turbulent growth. And, on the other hand, the expenditures for space research are extraordinarily great. At one time, Academician L. A. Artsimovich defined science as a means for satisfying the curiosity of scientists at the expense of the state. But space research is not at all an inexpensive means for satisfying this curiosity. Therefore, the adoption of decisions regarding the main directions to be taken in the development of space research has always been coupled with a heavy burden of responsibility.

During the development of the Soviet space program, we had an opportunity to discuss our own approach at the International Space Forum, which took place in October of 1987, in Moscow. At the forum, we stated to scientists from 35 countries our own firm conviction that space research should not become an arena of competition and rivalry. And the economic aspects are by far not the least important factor. For that very reason, it is very important to explain why so much effort is being expended and enormous amounts of resources are being spent, while, within the framework of the scientists' international cooperation, it is necessary to look for ways to do this more cheaply.

[Correspondent] Thus, it is possible to say that space research is already quite a "mature" field of science that, in your words, is now blossoming. What would you list as its most fundamental achievements in our country and abroad?

[Sagdeyev] I consider one of the biggest yet achievements in the field of space research to be the discovery of the earth's radiation belts and magnetosphere. It is no accident that, even today, the earth's magnetosphere, with its own complex plasma dynamics, particle acceleration and instabilities, continues to interest many scientists. A great deal of work is being performed in that field, and special satellites are being launched. A number of hard-to-measure processes, such as shock waves, the recoupling of the magnetic field's force lines and turbulence, make it necessary to perform new generations of experiments. In order to understand the cause-and-effect connections between events in the complex solar magnetosphere-ionosphere system, it is necessary to probe its various critical regions simultaneously, using a broad network of satellites and ground stations which operate in conjunction with them.

Thus, the Interbol project currently being prepared is intended for investigation of near-earth outer space using a system of probes. This project, planned for the years 1990-1991, includes two Prognoz-type satellites, each of which will have its own subsatellite. Interbol's basic task will be the study of the physical mechanisms responsible for the transfer of the solar wind's energy to the magnetosphere, for the accumulation there of this energy and for its subsequent dissipation in the magnetosphere's auroral regions, in the ionosphere and in the earth's atmosphere during magnetospheric substorms. One of the satellites—the "tail probe," with its own subsatellite—will be placed into an orbit which will pass through the tail of the earth's magnetosphere, which is an energetic reservoir of magnetospheric substorms; whereas the other (the "auroral probe," with its own subsatellite) will be placed into an orbit which passes through the region above the so-called auroral oval at an altitude of 5,000-15,000 km. Typical of this region are the charged-particle acceleration processes and the presence of electric currents, which couple the electromagnetic field in the magnetosphere's tail with the conducting ionosphere. Along with these experiments, studies will be made in the Interbol project of the plasma and the magnetic structures of the far regions of the magnetospheric tail. In order to do this, plans have been made to use instruments on board the Relikt-2 astrophysical satellite.

Furthermore, in answer to your question, I want to note that our ideas about the solar system's planets have changed considerably. Now we have an opportunity for making direct contact with them. And this applies primarily to Venus, which we began to study using space technology resources more than 25 years ago, over which time we have sent 18 spacecraft to it. We managed to obtain, first, black-and-white images and, later, color images of the planet's surface at the landing sites of these craft. The elemental composition of the soil was determined in situ, i.e., a quite complicated technical problem had been solved. The use of radars made it possible to obtain a radar map of the planet's surface and to determine its typical morphological features. A great deal of attention has been paid to the investigation of the atmosphere and the cloud layer on Venus. A lot of new and interesting data—not just about Venus, but also about Halley's Comet—was obtained during the Vega mission, but that has already been recounted in detail in PRIRODA, and I will not dwell on it.[1] Thus, summing up certain results, I can say that the study of the planets will remain a very important area of research for several decades to come; of this, I have no doubt.

Astronomy, in going out into space, has received an opportunity to see the universe in a new way: ultraviolet and x-ray observations have been added to the observations in the optical and radio frequency ranges, and γ quanta are being recorded very reliably. At this very minute, the x-ray telescopes of the Kvant observatory are making observations of the supernova which exploded in 1987 in the Large Magellanic Cloud. For the first time, astronomers can investigate directly the processes which occur, it can be said, at the nearest approaches to neutron stars and black holes.[2]

[Correspondent] In your opinion, what has space research given and what might it give to the other fields of science? And, in connection with this—is it possible to speak even today of some kind of practical return from the biological or, for example, production experiments in space?

[Sagdeyev] From my point of view, the biological experiments are an independent field of space science. First of all, they have made it possible to get an idea about the capability of the human body, or generally any living thing, to exist and function in zero-gravity conditions. I cannot begin to say what practical importance they will have in the coming decade (in addition to, of course, those relatively brief—several months—cosmonaut flights, of which we are currently witnesses). But, if, after about 20 or 30 years, a manned flight to Mars still takes place, it will be a rather complicated mission, since it will require that man's stay in space be extended to as much as two to three years. I reiterate that, for the time being, it is difficult to talk about some kind of practical return from, for example, space biology for medicine, but, as a physicist, I would say that it is extremely interesting to study a substance under extreme conditions—at high pressures and high, or conversely, extremely low temperatures; this immediately helps extend the limits of our ideas about the phenomena under study. If, for contemporary medicine and biology, the absence of gravity is an example of such extreme conditions, then I think that interesting discoveries are possible on this path, but, I reiterate, it is difficult for me to make a judgment about this.

I would apply this very same principle of evaluation to technology as well, in particular, to the growing of crystals under the conditions of weightlessness. Unfortunately, no decisive step has been made in this direction. Every now and then, there are reports about certain minor achievements, but it seems to me that we are still a long way off from any substantial knowledge or any serious incorporation of those achievements into our earth-bound practices. I would say that a vacuum developed for a period of time in this field, and serious specialists in solid-state physics—the ones who determine the direction of development of this science here on earth—did not enter the field. As a result, the vacuum was filled by engineers hurrying to get something introduced a little faster. For the time being, unfortuately, the situation is changing very slowly. Apparently, it is our academy who needs to take decisive steps to correct the situation that has developed.

[Correspondent] After a brief hiatus, the Soviet space program has again turned toward Mars. I am referring to the Phobos project, which got under way in June of 1988 with the launching of two unmanned interplanetary vehicles to Mars and its satellite, Phobos. As is well known, this is a multipurpose program which provides for an variegated investigation of the planet and its satellite, the sun and interplanetary space. Phobos should be the first small body of the solar system whose surface will be reached by a space vehicle. More than six months have passed since the launch of the spacecraft. Have you managed to get any kind of interesting results over this period of time?

[Sagdeyev] I would like to remind you that, on the flight path to Mars, the majority of scientific instruments have not yet been turned on; nevertheless, the first and, it seems to me, interesting data have already begun to arrive.

For example, included in the project's scientific mission were Soviet-French experiments on the study of gamma radiation from solar flares and gamma bursts from neutron stars. Conducting these measurements simultaneously aboard near-earth satellites and interplanetary probes will make it possible to locate very precisely space sources of gamma bursts and to make stereoscopic measurements of solar flares (indeed, now, besides the Phobos vehicles, gamma bursts are also being recorded by two American satellites—SMM and Pioneer Venus). On the flight from Earth to Mars, the Phobos vehicles' instruments were working continuously and were recording gamma bursts over an interval of 1-3 days. Thanks to

the high sensitivity of the detectors and the use of microprocessors for preliminary processing of the data, it has been possible to measure the time structure of the γ bursts with a resolution of around 1 ms. It is already clear that the bursts' spectra have a complex, multicomponent pattern and change in a matter of fractions of a second. After joint processing has been performed on the data obtained from all the space vehicles, the experimenters hope to determine the location of unknown γ radiation sources (both in the sky and on the sun's disk) with an accuracy of several seconds of arc.

And I would like to talk about one more result obtained, since it concerns plasma physics—a field that is closest to my scientific interests. The Phobos vehicles' instruments have located the intersection of the shock wave front at the boundary of the earth's magnetosphere, and the intersection was a repeated one. This affected the relatively slow motion of the spacecraft in such a fashion that it seemed as if the shock wave front would run ahead and then drop back. As a result, we have obtained approximately a dozen such intersections. It must be said that, in and of itself, the intersection of the shock wave front is not of much interest on earth. But, for us, this was an extraordinarily important test which proved that the instruments aboard the spacecraft were operating properly. We are now firmly convinced that the equipment's sensitivity is so high that we have reached a world-class level in plasma measurements. I am talking about the APV-F instrument—the plasma wave analyzer.

Similar such instruments were also on the Vega probes, but the situation was different at that time: the plasma activity of Halley's Comet was so great that we were not the least bit concerned about whether the sensitivity of the detectors was adequate or not. But in the Phobos project, a number of very delicate tasks had been set up which require that the equipment have enhanced sensitivity. The specialists have no doubts that we will be able to study the shock wave in the vicinity of Mars; but it will be much more interesting to observe how a small satellite, with a diameter of 20 km all told (I am talking about Phobos), moves within the plasma—after all, it will create disturbances of a much lesser intensity.

This experiment turned out to be the last one in which Frederic Scarf—the well-known American physicist and researcher of the solar wind and the magnetosphere and a great and long-time friend of our institute—participated. He was also engaged in the Vega project: Phobos became his last creation—Scarf died suddenly, literally several days after the launching of the vehicles. We are now preparing for publication the materials that were obtained. I recall this because it was Scarf who, several years ago, discovered a very interesting graphic method for representing the results of the investigation of plasma oscillations with these types of intersections of shock waves or other similar regions. The idea is a simple one—the spectrum of the electrical and magnetic oscillations which are characteristics of these types of processes lies in the region of what for us are the customary sound waves. Scarf simply converted the electromagnetic noise into sound, and an unusual polyphonic music was obtained—an actual "sound picture." This technique was used for the first time during the investigation of Jupiter's magnetosphere by the Voyager interplanetary probe. I hope that this time we will also reproduce the "music" of Mars and Phobos according to Scarf's recipe.

[Correspondent] Unfortunately, on 2 September 1988, contact was lost with the Phobos 1 probe. How will this affect the entire research program,and what is being done in connection with this?

[Sagdeyev] Of course, this was a heavy blow for us. On 6 September 1988, at 5 pm Moscow time, a telegram with the following content was sent to the members of the international cooperative who were participating in the project: "The Control Center has informed us that Phobos 1, because of an error in a command, lost its attitude and is not responding to signals from earth. The Control Center is attempting to re-establish contact with the spacecraft. We will keep you informed of the situation."

So far, the situation has not changed. All kinds of measures are being taken to re-establish contact with the vehicle. Evidently, it will be very difficult to do this. But, so long as there exists even the slightest theoretical possibility of getting in contact with Phobos 1, such efforts will not cease.[3]

With regards to the scientific program of research, I would like to remind you that two vehicles are taking part in the project and, to a large extent, they duplicate one another, although, unfortunately, not in everything. There are several instruments on Phobos 1 that are not on Phobos 2. Primarily, I am talking about the Terek instrument, whose tasking included investigation of the sun's x-ray radiation. It was developed by specialists from the USSR and the CzSSR. Now we are deprived of a lot of unique scientific information, and this is extremely disappointing.

[Correspondent] One cannot help remembering how successful the Vega mission was just two years ago, despite the fact that this was the first multipurpose project. Undoubtedly, the performance of such space projects is a very difficult matter in which nothing is trifling and it is too expensive to have to pay for errors. Obviously, the role of the scientists must increase. Is this not what you had in mind in your speech at the International Scientific Council on the Phobos project, which took place at the USSR Academy of Sciences' Space Research Institute in June of 1988, when you called for an end to the "hegemony of the producer?"

[Sagdeyev] I would say that everyone is familiar with the concept of the hegemony of the producer in our economy, on a personal basis, and all it takes, for example, is to go into any store. In actuality, this phenomenon is, of course, much more widespread and, unfortunately, those who work in cosmonautics also feel the effects of the faulty system which has come about in our economy. For example, the numerous—from the first to the sixteenth—Venera-series craft appeared not at all because our scientists were reaching out toward Venus so very madly; rather, it was simply a matter of this: it is either Venus (in the extreme case, Mars) or nothing. And quite often, it was necessary to contend with the fact that there was no real competitiveness between the industrial enterprises which specialized in this area. In each specific field, monopolies emerged, and, as a result, the scientists had almost no choice.

Moreover, it was even necessary to put up with them banging their fists on the table at you. Unfortunately, this practice still persists, as was demonstrated by the recent events associated with the analysis of the situation on the Phobos 1 craft. Evidently, glasnost and democracy will come to the aerospace industry last. It seems to me that all too often, in general, people take refuge in "secretiveness" in order to make life easier for themselves. I attribute this primarily to those managers who lack adequate capabilities for conducting their own affairs in a professional (and—as a consequence—successful) manner.

[Correspondent] Nevertheless, one would very much like to believe that, in the end, glasnost and democracy will come to all the spheres of our life just the same. But, it is still not clear to me why, before recently, it was Venus or Mars that was selected as the research project?

[Sagdeyev] For each space project, with its own scientific or technical sparkle, it is necessary to develop an appropriate spacecraft. In order to do this, the designers, together with the scientists, create technical specifications that, each time, are new. But, in our case, the task consisted of trying to use an already existing "machine" over and over again. We were simply lucky that, in its time, the craft of the Venera series was thought up and its first models developed by such a remarkable enthusiast as G. N. Babakin. One can only marvel at the longevity of these craft: after all, with a design developed on the basis of them at the end of the'60s for the flights to Mars (recall Mars-3 through -7)—with certain modifications, of course—we managed in the middle of the'80's to pull off such a complex, multipurpose project as Vega.

That is why I want to emphasize once again that competitiveness should be incorporated in the system from the very start, and then it's a matter of the consumer (in this case, the scientist), based on his own interests, selecting the best, the optimum version of the design effort.

[Correspondent] Then, will what is now being planned to be done during the Mars 94 project also be an example of such competitiveness?

[Sagdeyev] Everything depends on how perestroyka goes. In fact, there are still a lot of little nooks and crannies (quite a few) into which, for all practical purposes, it has not yet penetrated because of "secretiveness." But, I am hoping all the same that, by 1994, we will develop a good project. And it is very important that, from the very beginning, the principles of scientific democracy and glasnost extend to all our international cooperation among scientists. In fact, we have managed to establish at the Space Research Institute quite a remarkable, informal scientific association which includes the laboratories of 15 countries, and, in certain projects being developed at this time, the number of participants is even greater. The main thing is for everyone to realize that each member of such international cooperation has a right to his own opinion.

And, in my opinion, it is quite unimportant that competing versions developed by two industrial enterprises for the Mars 94 project propose the use of different launch vehicles—either the Proton or the Energiya, i.e., the space probes will differ in the overall weight of the scientific package sent into space. The main thing is that, during the process of the preparation for this project, the element of competitiveness emerge immediately. Indeed, each of the groups, in proposing its own design version for the flight to Mars, is now trying to find the most interesting features of its own scenario in order to show that its design is the one which will enable science to get what it wants, and to the fullest extent.

[Correspondent] There are differing schools of thought on manned flights, particularly to Mars. Do you count yourself among the proponents of such flights, or are you for the unmanned probes?

[Sagdeyev] I consider manned flight a very important measure. It cannot be based only on the need to solve certain scientific problems. It also has a very important political aspect, inasmuch as it is its own kind of counterweight to purely military projects such as, for example, SDI. But, at the same time, it must be clearly understood that this is also still a very complex project. It is clear that no one is ready to do it today: the equipment needs to be developed, and more information must be obtained about Mars itself and about what we call its "engineering model." I am talking about the collection and assembly of the data which must be available to the engineers and designers in order to develop the unique equipment, put it into a Martian orbit, and then perform the flight and landing through the planet's atmosphere under little-known conditions.

Now in this first stage, as a precursor to manned flight, there absolutely must be unmanned missions by robot vehicles. They need to be planned as the first links in a

long chain of flights. In fact, even today, we need to think about a general line of research and not simply "snatch out" some individual flights.

[Correspondent] But does such a general line exist at the present time? And can you say something about the difference between the strategy of the space program in our country and that in the West?

[Sagdeyev] I can freely assert that we have such a line of research. Thanks to glasnost, which made its way into our space science very swiftly, we simply were prepared for this, understanding that it is impossible to work otherwise. We have been able to express and approve our own point of view on the development of space research (of course, this point of view is not something hard and fast—it is continuously developing, and we are taking into consideration our partners' suggestions as well). This point of view has now become, I would say, a generally accepted concept.

Good orbital craft must first be developed, then descent modules must be landed on the surface of Mars, and then the landing craft must be made to move about the planet's surface, i.e., turn it into a Martian excursion vehicle and teach it to overcome obstacles and traverse the various geological and climatic zones of Mars. It is possible that, along its path, it will detect some signs of life or, at very least, traces of organisms which existed at one time.

[Correspondent] Do you consider the question "Is there life on Mars?" still open?

[Sagdeyev] Yes, it seems so to me. In any case, our duty is to use all of the flights to this planet to obtain a definitive answer. A negative answer will also be extraordinarily important.

Subsequently, in the course of a discussion on the Mars 94 project, our foreign colleagues proposed adding to the above-described scenario yet another launching of balloon probes and even advanced a very interesting idea for their design: a double envelope—one filled with helium and one with hot air—which would "lie down to sleep" at night and then, in the daytime, through the action of the solar rays, rise up once again and continue its own flight.

The next stage, also unmanned, involves the return of soil samples from the most interesting regions of Mars to Earth. If, by this time, equipment has been developed for travelling across the surface of Mars (and it requires not only an unusual design for a self-propelled vehicle, but also, in essence, actual artificial intelligence, which would control the Martian excursion vehicle), then we can count on such a vehicle to gather samples of material in the most diverse regions of the planet and deliver them to a rocket waiting to be dispatched to Earth.

This is one such scenario and sequence of operations which, in my opinion, can quite realistically be accomplished in this century. It is very important that the projects be international ones—then they will cost each of the participants a lot less. After all, we can no longer allow ourselves the luxury of thoughtless competition—who will get a launch off first—with the parallel expenditures of enormous sums. But, the main thing is for all of us—the project's participants—to feel that we are the ambassadors of a single, small and, unfortunately, rather fragile planet, the planet Earth.

[Correspondent] In the spring of 1988, you were in the USA, where you met with American scientists and politicians. Was the possibility of a joint preparation and flight to Mars discussed? If so, what was achieved in these talks?

[Sagdeyev] To date, our meetings with the American scientists are proceeding in this manner: we are exchanging ideas and, I would say, working out what are still just speculative scenarios. There is enormous interest on both sides (by the way, it's in Europe also). But the matter of an agreement is already being touched upon by the highest leaders of both countries. You know that M. S. Gorbachev, in his own speeches, has several times dwelt specially on the subject of joint Mars research. Of course, his interest inspires us. But that the same kind of enthusiasm needs to be displayed by the American administration. It had no time just then, for as you know, the election campaign was going on in the United States, but we are hoping that the new administration will regard these space projects with greater interest.

Yet, all the same, after the Moscow meeting, some changes had begun to show in the top levels. For example, we were given the opportunity to discuss officially the approaches to this problem (I am talking about the flight to Mars) with NASA administrators. For the time being, we are exchanging views on the unmanned scenarios of the Soviet flight to Mars, with an eye to starting up, sometime in the future, a discussion on joint missions.

[Correspondent] As is well known, the cost of both multipurpose space projects—Vega and Phobos—is quite high. Errors and malfunctions in the program can cost dearly. Would it not help here to have mathematical modeling of the planned experiments?

[Sagdeyev] In any field of science, not just in cosmonautics, mathematical modeling is now becoming an imperative and a necessity. That is how it was during the Vega project: we attempted to model a large number of phenomena and processes long in advance of the launch of the space vehicles. The very same thing occurred during the preparations for the Phobos project as well. Thus, all the ballistics were constructed on the basis of mathematical modeling; the same can also be said about many other experiments. And the farther we go, the more we need to resort to mathematical modeling.

Therefore, we are counting very much on the appearance of the supercomputers. For us, they are not prestigious toys, but rather, primarily, instruments with which it is possible to carry out a considerable portion of the operations. Of course, this does not replace actual physical modeling, but, it assists it to an enormous degree. And who knows, it is possible that it will replace it in the future! Unfortunately, for the time being, we can not get domestic supercomputers.

[Correspondent] What's the reason for that?

[Sagdeyev] During the notorious stagnant years, when the progress of our entire society was slowed down, including the development of many important areas in science as well, there appeared yet one more sad feature—reports to the leadership which embellished reality extremely skillfully. This created the semblance of well-being, at both the top and the bottom. And, as a result, entire scientific areas were neglected. Now they need to be developed vigorously.

But this problem has another, no less terrible aspect—the young scientists and engineers who are working on various projects and witnesses their supervisors skillfully "pulling the wool over people's eyes," are simply losing heart. Or what is worse—they themselves are beginning to work differently, and the same "wool-pullers" are emerging among them. And that is the most terrible thing!

[Correspondent] Nevertheless, one would like to believe in the enthusiasm and reasonable optimism of our youth and to count on their creative potential. And so, the research on the Phobos project is now in full swing. But, certainly, discussion of and, possibly, preparations for other, no less important space programs are going on at the same time. Which of them in our country and abroad would you take particular note of?

[Sagdeyev] In fact, right now, the Phobos project is, without a doubt, at the center of the international community's attention. As the interplanetary probes get closer to Mars, interest in it will only increase.

But one more remarkable scientific event is taking place in 1989—the American Voyager spacecraft, after its encounters with Jupiter and its satellites, Saturn's system and Uranus, will approach the planet Neptune. This is an example of unusual space longevity. We are all extremely delighted and, to be honest, terribly envious. But I want to emphasize that, in this instance, to an enormous degree, everything is being determined by the extremely high production efficiency with which this craft was developed. Indeed, its entire system, as a whole, and each individual small component—be it a microcircuit or a capacitor—needs to be able to operate for many years under extreme conditions (increased radiation, enormous temperature differentials and so on), without human intervention.

[Correspondent] Just how long has this space "Methuselah" been functioning?

[Sagdeyev] It was launched in 1978, so it has already been in flight for more than 10 years. But even this is not a record. Sometimes, as a joke, we are sent invitations to a banquet for the occasion of, for example, the 15th anniversary of Pioneer 6's continuous operation. That craft is a predecessor of Voyager; and there are many such craft. And our mouths are just watering—after all, we don't have anything like that!

In the next few years, one more remarkable project is supposed to be accomplished—the placement into space of a 2.5-meter space telescope which has been named the "Space Telescope" or "Hubble Observatory." It is a unique instrument; as soon as it is placed into orbit, astronomers will see much farther than they can with any powerful ground-based telescope; but the main thing is, they will see in a different way, because the telescope has a completely different wavelength reception range (not only the visible band, but also the ultraviolet band of the spectrum), and, in addition, gigantic angular accuracies are characteristic of it, inasmuch as the atmosphere does not interfere and does not create scintillations.

But this instrument has become a victim of the Shuttle project. The fact is that, in the last decade, the American space program has contained an innate flaw—all the space projects have been tied to a reusable craft, the shuttle. This represented direct political interference (an example of command-and-administrative methods of leadership), the result of an unfortunate decision and the fact that the opinions of scientists and engineers were not taken into consideration. Now even the NASA administrators have found within themselves the courage to acknowledge the error (and what is more, they consider it to be history) and now, along with the reusable ship, they are developing (and re-establishing) a whole range of ordinary, single-use launchers. But the space telescope and its mechanical interfaces have been constructed in such a fashion that they are all tied only to the shuttle, and, therefore, it is difficult to say exactly when the telescope will be placed into space. I can only note that our American colleagues have been extremely perturbed by the existing situation.

Several other projects are also in a similar situation. For example, Galileo, which involves the flight to Jupiter and the release of a "landing party" into the planet's dense atmosphere. It is such a pity that the American specialists did not take advantage at the time of our suggestion that they order Soviet launch vehicles for their program. Now it is already too late, but, certainly, a year and a half to two years ago, it would have been possible to consider this.

[Correspondent] But why is it too late now?

[Sagdeyev] The reason is the very same one—the complicated mechanical interfaces which I spoke of in connection with the space telescope project, and, in the case of Galileo, very extensive changes are required, while the shuttle flights have already recommenced.[4] But there are a whole series of other space projects—and not just scientific ones, but also commercial ones—which we are preparing in our country, in which the West could participate, and which would also be very beneficial for them. This would be mutually advantageous. But, again, political considerations are interfering. For purely political reasons, the United States did not want to take advantage of the services of our space industry.

[Correspondent] You have listed the most interesting American space projects. But how do things stand in our country?

[Sagdeyev] We currently have ready two astronomical satellites (one may be launched in early 1989, and the other in mid-1989). Primarily, I am talking about the Gamma Observatory (a joint Soviet-French project). Its launch dates have already been postponed several times. This is very disturbing to us, and it is with great reluctance that we are agreeing to the routine postponement of the dates about which Glavkosmos is reporting. We are very hopeful that, this time, the launch date for the Gamma Observatory will not be postponed.

[Correspondent] Why are the dates being postponed?

[Sagdeyev] I think it is a result of the same basic problem from which our entire economy suffers—a lack of responsibility.

The second astronomical satellite is the Granat X-Ray Observatory. This project was born several years after Gamma, and, therefore, it is more modern and has instruments that are more precise and sensitive. This is also a joint Soviet-French project. I think that, if both observatories are placed into orbit without further delays, they will make their own mark in space science. But the United States may surpass us, as they have ready the GRO [Gamma Ray Observatory] satellite for gamma ray astronomy; the weight of its scientific instrument package is four times greater than what is on the Gamma Observatory. It is also waiting for a launch vehicle—the shuttle is also supposed to place it into orbit.

[Correspondent] More and more countries are beginning to develop their own space research. The establishment of international cooperatives in this field is no longer a rarity; you yourself have repeatedly mentioned this in our discussion. Is it not already time now to develop clear-cut international statutes on space?

[Sagdeyev] Regardless of what the international legal norms are, relations between the space powers will depend on the political goals which the partners pursue. But frameworks within which these goals could be accomplished, reliable and firm, are undoubtedly necessary.

Even now, there is a whole series of international legal norms (for example, the ban against placing nuclear weapons or other weapons of mass destruction into space). From my point of view, they need to be supplemented by a rejection of the militarization of space in the broad sense, i.e., also banning the testing of any weapon in space. A proposal has been made that a series of legal agreements be concluded regarding the use of outer space in the national economy or for economic purposes.

Thus, this field already has its own science—international space law. This science is developing and, from time to time, there are international conferences and seminars, and everyone associated with space is interested in the development of this sphere of activity.

[Correspondent] Roald Zinnurovich, in our conversation, you have talked about those space projects which are either already in full swing or will be conducted in the next few years. But what about a look into the future? What kind of space projects do you foresee for the 22nd century (in fact, there are only 11 years left until the beginning of the 21st century)?

[Sagdeyev] It is a shame to admit it, but the realities of our practical economic affairs reduce the role of the leader of any scientific collective involved in space, be it the director of an institute or the head of a laboratory, to one of spending nearly 90% of the time on the solution of immediate problems—"forcing through" orders, and not just such grandiose ones as an order for a satellite or a subsequent launch, but also for an instrument which is supposed to go up; getting the individual component assemblies which may or may not be produced by our industry—and all of this represents an enormous amount of work. And, in the end, it turns out that, in that set of everyday current affairs, which, with proper organization of the country's economic system, should not eat up so much time, we are not in a position to even think about projects in the 21st century, let alone the 22nd century.

Nevertheless, I am hopeful that, in the 21st century, we will witness the free travels of man within the limits of the solar system, even though, true, it may not be us, but rather, our descendants. I think that, during the next approach of Halley's Comet in 2061, mankind will certainly succeed in unraveling its mystery. Certainly, it would be dangerous to land a manned spacecraft on the surface of the comet's core, but, who knows, it is possible that, by that time, protection against the dust streams will have been developed. In any case, taking a sample of material directly from the comet's core and delivering it to earth will turn out to be a readily solvable problem for our descendants (and I do think that our children's children will live to see this event).

[Correspondent] What do you mean by the mystery of Halley's Comet?

[Sagdeyev] Today, we can not answer many of the questions about the physics of comets—for example, why this comet behaves so unusually. All it has to do is approach to a given distance from the sun, and then, over the course of several weeks, it continues to "stew" with tremendous intensity. Such thermal "memory" of a comet is retained for a long time. Inasmuch as we know the heat capacity of its matter, we can make approximate estimations, but, based on them, such an evaporation process is not supposed to last so long. Meanwhile, the comet continues to "stew," and much more intensely than it did at the same distance from the sun during its approach. The nature of such asymmetry is not understood. Evidently, there occur on the surface of the comet's core some unknown physical and chemical processes which we have not yet been able to investigate fully.

And finally, there is the matter of the comet's origin. It has yet to be solved. In order to do this, it will first of all be necessary to deliver cometary matter to earth.

[Correspondent] The next question extends beyond the framework of our present conversation. Keeping in mind the social and political events and the process which are taking place in our country, what is your understanding of democratization and glasnost in science and how, in your opinion, should the USSR Academy of Sciences reorganize its own work?

[Sagdeyev] It seems to me that our academy has its own unique and special place in the worldwide family of scientific societies. Once elected into the academy, its members receive such a bouquet of privileges as is not possessed by a member of any other academy in the world. I am not talking simply about additional material goods; in the final analysis, the processes which are going on in the country (including the inevitable inflation) are gradually diminishing this difference and, later, it will be reduced even more. What I am talking about is that, in addition to the respect, which is also enjoyed by members of foreign academies (in fact, election itself is an act of recognition of their services), the members of our academy receive levers for influencing scientific policy as well. As a rule, the academicians head up institutes and, if one of the institutes is unable to secure for itself an academician as the director, it simply considers itself a poor relative. Very frequently, regardless of the scientific merits of the director of such an institute, an attempt is made during the regular elections to the academy to "correct" the situation. Moreover, influence on the scientific policy is achieved through the USSR Academy of Sciences' Sections, Departments and Problems Councils, which are headed up by academicians. As a result, thousands of first-rate scientists—doctors and candidates of sciences, those who, because of an unfortunate twist of fate, did not manage to become members of the academy (and there are many such cases)—have, to a large extent, have been excluded from the actual process of conducting scientific policy.

Therefore, democratization in science, first and foremost, should liberate the gigantic creative potential of the main group of people who create science.

[Correspondent] What, specifically, do you suggest be done?

Possible measures are being discussed rather widely and the president of the USSR Academy of Sciences, G. I. Marchuk, has repeatedly spoken out about this, particularly in the press. There was talk about greater and greater autonomy for the departments and about transferring authority from the level of the presidium and the sections to the level of the departments. This idea immediately received support, but it became clear rather quickly that, if the departments concentrate all the absolute authority in their own hands, then, in the final analysis, it will be a restoration of the ministerial main administrations which are being condemned currently.

At the present time, the process of revitalizing the institutes is going on; they should receive greater autonomy. Therefore, in my opinion, the next step is the institutes' use of the obtained rights and genuine democratization inside the institutes. Many different measures exist for bringing this about. First of all, elections of the institute's director and the members of the academic council. It should be said right off that I am against these elections being turned into an uncontrolled veche [ancient Russian public assembly]. Because then the opinions of people who are not competent and who are somewhere on the periphery of science are, in essence, equal to the opinions of the specialists, and, as a result, the election process (just like any other) becomes uncontrolled. But, of course, the voice of each scientific associate must be heard.

Furthermore, I feel that the democratization of the institute's scientific affairs should include the further transfer of authority (including financial and economic) to the laboratories, which should become the basic unit in the scientific community. It is necessary to conduct a search for new forms for financing the scientific collectives on competitive bases and to develop competitiveness between them. And then our scientists, many of whom have worldwide recognition, will actually be able to influence scientific policy in this country, and it will not be controlled by only a narrow, private circle of academy members. It is then that our science will actually take a real step forward.

At the same time, of course, it is also necessary to improve greatly the material conditions in which science is developing. Because, granting a laboratory autonomy without giving it the capability of acquiring, for example, a computer, is the same as just doing nothing.

[Correspondent] You were a delegate to the 19th party conference. What made the greatest impression on you at that most important event in our country's affairs last year?

[Sagdeyev] The speech by M. S. Gorbachev, and for the scientist—especially that section of his report which was devoted to science. At that time, I got the impression that, in that report on the problems and needs of our science, everything was said that I myself wanted to say. Perhaps, to some degree, the lackluster reaction of the party conference delegates to the speeches by the leaders of our academy can be accounted for by the fact that it was difficult to add anything new.

But what really annoyed me was the offhand manner in which many delegates "wiped their feet" on science. As an example, I will refer to the speech by the general director of the Ivanovo Machine-Tool Production Association imeni the 50th Anniversary of the USSR, V. P. Kabaidze. I would even say that, in some sense, such a style would be more appropriate at a Gennadiy Khazanov concert. With such an attitude toward science, even the organizational and economic talent which Comrade Kabaidze undoubtedly possesses will not help our industry to move Soviet technology to the leading edge.

I understand what the roots of such an attitude toward science are. Indeed, over the course of many decades, particularly during the period of stagnation, our science was a "pocket" science—nobody thought about us until, basically, it was necessary to substantiate, for example, a routine decision about a new general assault on nature. And now, a reverse wave has emerged. It is completely legitimate to question the moral and social integrity of the scientist. It is no accident that discussions centering on specific facts—for example, the polluting of Lake Baykal or the notorious diversion of rivers—and on the names of the specific scientists who personally participated in those sadly familiar decisions are not fading away.

In many respects, we ourselves are to blame for the fact that a loss of interest in science and skepticism with respect to it are now being observed. And here, an enormous role belongs to the promotion of the achievements of science, since science and its importance are served by the mass media's resources. One idea is to publish a special USSR Academy of Sciences newspaper; the president of the USSR Academy of Sciences made such a proposal at the conference.

[Correspondent] Are you talking about one more popular science publication, of which, it would seem, there are quite enough, or something totally new?

[Sagdeyev] The basic aim is to make all the scientists and all the members of the scientific community feel that they are one family and to see to it that feedback is faster and not as slow as, for example, the feedback with the currently published magazines. This is why it is necessary to have, if not a daily paper, then at least a weekly paper.[5]

But even that sort of newspaper will not solve the problem of the promotion of the achievements and role of science among the broad masses, since the scientists will basically be the ones reading it. Here also, I support the idea expressed recently by Academician L. I. Abalkin: it is necessary that one of our major newspapers, for example, PRAVDA, once a week, set aside a whole page for science. It is possible that IZVESTIYA would be better suited for this purpose (but not SOVETSKAYA ROSSIYA!).

In general, it should be noted with regret that there was recently a page in some publications for para-science. But it is not new. I remember, about 12 years ago, I gave a popular lecture in Gosplan's large lecture hall. An enormous hall, and hundreds of workers. My speech was devoted to the use of the achievements of cosmonautics in the national economy. At the end of the speech, they began to put questions to me—orally and in the form of notes. There were about 20 notes, and they were all devoted to one topic—flying saucers! I opened one after another, expecting a question actually relating to the theme of my speech. But when I opened the last one and saw that it contained that very same question, I could not take it anymore and shouted in a fit of temper: "Now that I know what kind of space research interests Gosplan's workers the most, I understand why we have such a mess in the national economy!" Academician M. V. Keldysh laughed for a long time when I told him about it all, but then he noted: "But you really acted very carelessly—the financing of scientific research depends on them."

I think that, back then, we put ourselves too often in the position of the junior partner, and we did not courageously defend the interests of science. I hope that those times are gone for good.

[Correspondent] In conclusion, Roald Zinnurovich, all that remains is for me to thank you for an interesting and substantive interview. I hope that PRIRODA's readers will have the chance to hear from you again and again about the achievements and problems of space research—one of the youngest and most promising areas of science.

Footnotes

1. L. S. Marochnik, G. A. Skuridin, "Rendezvous With Halley's Comet," PRIRODA, 1982, No 2, pp 2-18; V. M. Balebanov, V. I. Moroz, L. M. Mukhin, "The First Stage of the Vega Mission: the Study of the Venusian Surface," PRIRODA, 1985, No 6, pp 3-12.

2. Yu. N. Yefremov, "The Explosion of a Supernova in the Large Magellanic Cloud," PRIRODA, 1987, No 6, pp 102-104.

3. Communications with the Phobos 1 vehicle have not been re-established. (Editor's note)

4. On 15 November 1988, our country also accomplished the launching of a reusable ship, Buran. It was placed into orbit by the Energiya rocket, and the landing was accomplished in an automated mode. (Editor's note)

5. Beginning in 1989, the weekly NAUKA I VYSSHAYA SHKOLA [Science and Higher Education] will be published. (Editor's note)

Cosmonaut Kovalenok Rebuts Criticism of Space Program

18660130 Moscow KRASNAYA ZVEZDA in Russian 10 Jan 89 p 2

[Article by Major General of Aviation V. Kovalenok, pilot-cosmonaut of the USSR and twice Hero of the Soviet Union, under the rubric "At the Crossroad of Opinions": "Black and White"; call-out in article reads "Space expenditures will pay for themselves 100-times over..." and is attributed to Academician and Chief Designer S. Korolev]

[Text] Glasnost, frankness, awareness of the fact that there are no themes today which are prohibited for discussion, and the desire to participate in the discussions of one or another of the disturbing problems have roused millions and millions of Soviet people to action and have moved them to take to an active, vital position. This fact is indisputable. And gratifying also. But the wave of pluralism, together with the objective and analytical assessments of what is going on and the constructive suggestions, has also brought with itself quite a few demagogic, subjective opinions which, while claiming to be "revolutionary" and a sign of civic concern, are in fact incompetence, reluctance (or inability) to examine problems thoroughly and seriously, and little more than evil, unrestrained fault-finding. Even our cosmonautics have not escaped such assessments (or more precisely, such attacks).

No, I am not at all about to idealize the state of affairs in this very complicated branch of science and technology, to close my eyes to the acute and serious contradictions, both "internal" and "external," or to walk away from the problems which need to be solved. But I cannot help saying that the path traversed by Soviet cosmonautics over a little more than three decades is convincing proof of the courage of the thinking, talent, and creative potential of our people and the industrial might of the country and the strength of its science. And if we are to speak of a sincere interest in improving matters in our field (forgive me for calling it that), then we should probably begin by analyzing causes and identifying specific defects and then proposing realistic ways of eliminating them.

Not everyone who wants to participate in discussions on a space theme likes that approach. And maybe they are incapable of such an approach. It's much simpler to sow the seed of doubts, to play with the fashionable phrases of "mature feasibility" and "awards of the highest honor," to note in passing that "space costs the state a pretty penny," and then to just pass on by. Let everyone see, they say, that it was I who daringly, boldly and with principle first raised the question, "Can we count on the space program becoming a profitable sector of the national economy?"

Nor was a serious, well-reasoned, interesting conversation on the economic problems of the space program to the liking of the author of the article "Money for Space" (KOMSOMOLSKAYA PRAVDA, 23 December, 1988)—or perhaps the author was incapable of such a conversation. Well, such things happen. Especially, when there is a violation of the very principle which the author recognizes: "amateurs should be barred from entering this field (the space program)" [B. Kovalenok]. Yet, all the same, I would like to express my own opinion of the article's "profound" premises with respect to throwing money down the drain and its judgments on the financial, scientific and technical, moral and, in general, human aspects of space travel. Especially since I am one of those on whom, for the testing of space equipment and for prolonged work in space, has been conferred with an "award of the highest honor."

The article in the paper, which we all respect and love, is addressed to the young people. The author tries to indulge them with his own feelings for the rock group Pink Floyd, to not offend our "Earthlings," and, at the same time, to oblige the restructuring of space affairs. But, as the object of criticism selected by him comes into better focus, then he figures on getting some bigger dividends.

Is it really acceptable today to select such a path and have the right to earn the confidence of the readers with false concepts and by branding abstract culprits who throw money away on space research and other anonymous specialists who cannot catch the "golden rain" which falls from orbit into the national economy's pocket? And then to build one's own opinions on a cooperative-ruble (or ruble-cooperative) philosophy and on the idea of reckoning income and outgo on the beads of an accountant's abacus and discover a discrepancy and use it to explain the shortage of trousers and shoes, of toilet paper and laundry powder, the Afghan problem, and the errors in international trade?

In reasoning thus, it is possible to arrive at absurd, primitive and somewhat frightful conclusions. Is ideology really necessary if there is no profit in rubles from it? Is an army really necessary, since it just spends, but does not produce? Is it really necessary to treat the sick and the dying, when it is known full well that there will be no profit from it? Are manned flights into space really necessary, when they "cost the state a pretty penny"? In a word, if there is glasnost, then yell louder. Then your standing in the ranks of the proponents of perestroyka will be even higher.

I do not want to reproach the author for wanting to look critically at the organization of space research in our country. I reiterate: this field of people's activities is in need of serious analysis. And this analysis should definitely contain an objective and comprehensive evaluation of what the space program has already given society, of what it is giving it now, and of what we have a right to expect from it in the future. It is necessary to be able to distinguish basic problems (and it is important to emphasize this) from applied ones, to see the trends and prospects, and to consult with competent and knowledgeable people, with theoreticians and practitioners, with designers and scientists, and with economists. Then, it is not necessary to make the stipulation: "I am not a specialist in commercial matters" and the like.

Without a doubt, the space program—which is complex in scientific and technical content, extremely difficult (and still associated with risk) in terms of practical realization, expensive in the economic sense, but also potentially necessary for humanity today—does not have the right to be on the sidelines, divorced from the processes occurring in the country, and to remain behind an impenetrable curtain of secrecy.

The times require changes. And they will take place. Some things have already been done. We have become witnesses to reporting right from the cosmodrome. We know who is preparing for a forthcoming flight and in the context of what program. How many Cosmoses, Molniyas, Meteors and other unmanned and manned space vehicles are launched every year and for what purposes. That may not be enough. Perhaps we could discuss in the press itself the plans for forthcoming work, research and experiments and conduct them on a competitive basis. That would make it possible to involve in space more of the organizations and departments which sorely need the findings of space flights.

Incidentally, the number of such organizations is estimated, even today, to be an extremely impressive figure—nearly 900. I could also list here other specific figures: What the return in rubles is from the photographs made by the cosmonauts for the ministries of geology, the fish industry, and land reclamation... I could convert into rubles the production experiments performed in weightlessness to obtain new materials with specified properties, superpure biological substances, unique medicinal preparations... I could add to that the return from the observations, research and experiments involving natural resources and environmental protection, glaciology and oceanology, the detection of forest fires and dangerous locust invasions, the assembly of astrophysical and other instruments, and the production of tens and hundreds of millions of rubles of profit.

But the author says nothing about all this. Why? And is this really fair? Today, some people see a commercial basis for space in advertising stunts. Similar things have been heard before: it has been proposed that money be charged for visiting the museum in Zvezdnyy Gorodok and that the cosmonauts' autographs be sold at a Riga market. That will not happen. In addition to bank capital, there is also another type—moral and human capital.

Incidentally, regarding Zvezdnyy Gorodok and the Cosmonaut Training Center imeni Yu. A. Gagarin. I've had occasion to be launched into space three times, to spend long years preparing for the flights, to back up my comrades, to communicate with the crews working **(working!)** in orbit, to go through the most complicated situations and to grieve for those who died.

There are no easy roads in space. And it must not be thought that only a veil of fascination and romanticism shines on this path. When one schoolboy—and children are always more straightforward and credulous than adults—dropped a similar phrase—"Just think, you flew into space. Two days, and already a hero!"—our comrade, Vladislav Volkov (he died together with Georgiy Dobrovolskiy and Viktor Patsayev), said to him: "My fine boy, the whole of our lives went into those two days!..."

Journalists frequently visit Zvezdnyy Gorodok. I think that they know what goes into the training and preparations for flights, and there are among them those who have, to some degree, experienced all this for themselves. I remember the lengthy and detailed conversations with them about our work. I also remember the questions concerning profitability and the discussions on that theme, with examples, figures and facts. I don't have a bad memory: it's a visual one, in general. But I cannot recollect S. Leskov, his interest in our work and in our cares and problems. I asked my comrades and they also do not recall any business-related contacts with the article's author: not on the questions of "philanthropy," not on other problems of the space program.

My comrades and colleagues, all without exception, know and remember our every step along the space path, from the plans and projects of K. E. Tsiolkovskiy to the recently completed yearlong stint of V. Titov and M. Manarov and the launching of the Energiya launch vehicle and the testing of the Buran shuttle. Moreover, there is also complete unanimity in the understanding of the fact that we do not have a right to demand a ruble return from the first artificial earth satellite in the history of our civilization, from the splendid launching and flight of Yuriy Gagarin, from the first excursion into open space by Aleksey Leonov or from the other momentous achievements (which have been acknowledged by the entire world).

We believe that whoever sets foot on Mars and whoever flies farther will be grateful to those who plowed the first, most difficult furrows in space, who risked their lives in the tests and who gave their all to space work. They will

be grateful to humanity. Just as, on the other hand, humanity will be grateful to those who, through their own labor and talent, paved the road into space for earthlings.

And it is not necessary to mix up black and white.

Institutional Barriers to Use of Space Photography Criticized

18660126 Moscow SOVETSKAYA ROSSIYA in Russian 3 Feb 89 p 2

[Article by L. Shevyrev, head research associate, Voronezh University, candidate in geological and mineralogical sciences, under the rubric "Opinion on an Acute Problem: "Forbidden View from Space"; first paragraph is source introduction]

[Text] Over a quarter of a century, numerous Soviet space expeditions have operated in orbit and used reliable photography equipment. The country has accumulated a rich bank of space photos. The number of frames its contains is hard to estimate, undoubtedly running into the millions. And this doesn't include the shots taken by meteorological satellites, in the millions themselves. As we see, we have a lot of space photos, and yet we don't. They are virtually inaccessible to the national economy, science, and the educational system.

A space image of the Earth's surface is not just a curious picture, but a highly accurate photomap of a segment of the planet from which the interference and errors due to the extraordinary conditions under which it was taken have been removed. The standard product of, let's say, the American Landsat is produced this way: The image from space is broken down into almost one hundred quadrangles; distortions are corrected; and then the computer draws a new, correct "photo," a true image of the broad expanse of land or sea. It is surprising, but the satellite's altitude, 900 kilometers, does not keep it from being able to determine the coordinates of any object below with an accuracy of 90 meters or more. That is the old Landsat product, or, figuratively speaking, yesterday's space photography. Now the control tie-in, like the minimum dimensions of the objects which can be identified from space, is figured in meters.

Much can be seen in these photos, and much can be understood. "Hard" science has used space photo materials for decades to solve fundamental problems. Unfortunately, space photos are virtually unused here for everyday, human needs or for "local" needs. Certain departments have not wanted to saturate the national economy with space information or to demonstrate the benefits of its use at every regional agroindustrial association or at many design organizations for the constant observation of the specific local ecological situation that concerns every region. They wouldn't let the photos out of their "clutches," i.e., their closed depositories.

We talk about computerizing the national economy—wonderful! But aren't space photos of the planet just as much a sign of modernity as a computer and a display? And this, our own material, on a par with the best in the world. Our knowledge of space photo information and our practical experience with it could bring the Fatherland great benefit.

In the meantime, we can be even more jealous of foreign practice. The Yugoslavs, for example, used Landsat's photos, not ours, to find natural gas shows in the northern Yadran-Adriatic Sea area. They demonstrated that gas rising above natural hydrocarbon deposits cools the water surface slightly—by a fraction of a degree. These "cold" spots are identifiable on space photos. They quickly identified 28 eight anomalies, 14 of which indeed corresponded to natural gas shows. Another four were close to shows, and another four corresponded to oil spots of unknown origin on the sea surface. And then a report was recently flashed in the newspapers: Yugoslavia had found new commercial oil fields!

Another example. A network of sensors was set up in the thermal zone of the Cascade Mountains, in the United States. Satellites passing over receive data continuously on the temperature of the rock in this hard-to-reach region, which is replete with powerful earthquakes, and inform the ground center about processes deep within the Earth. The goal is to learn early on about rumblings in the interior in order to warn the populace. An ever-present space watchman, wide-awake and accurate. One can't help but recall Armenia here.

But let's take a proprietor's look at our own boundless country. After every downpour, gullies "spring up" in Central Russia. Space photos provide an excellent picture of their spidery network. Constant monitoring of erosion processes—if the supply of space photos could be set up on the rayon and oblast levels and if people were taught to use them—would be a very beneficial state task. For a long time now, our black earth regions have not been as black as they once were. The processes by which humuses are washed out of them (the "lightening" on space photo images) can and must be monitored in this way in every region, on every farm. Just as the movement of a moisture front or the condition of the snow cover, of marshes, and of forests is monitored. Can kolkhoz chairman in their little Ulyanovsk jeeps, or foresters on foot, take care of everything?

Regional differences in natural conditions are so subtle and complicated, the tasks so diverse, that centralized hard science can't have formulas for every case—what kind of space photos, how to use them, for what purpose. It can't in any way replace practical experience or reflections on site. Comprehending a space image must be approached not from one's office, but from a wheat field, a borehole, a burgeoning gully, the deck of an expeditionary ship dancing on the waves.

For too long the prestige of space photos has kept them an object of study by very closed groups of scientists, which has brought tremendous losses to practice. Occasional lots of photos, which about a thousand organizations have barely managed to get their hands on, are a drop in the bucket to the actual users. The general director of the "Priroda" State Center, Yu. Kiyenko, somehow complained in the press that local organizations show little interest in the center's product. "Others probably genuinely feel that photos from orbit are hard to get. It's long been time to correct this misconception."

Unfortunately, the truth is even sadder! It has been repeatedly noted at various all-union scientific conferences that the USSR is still behind developed capitalist countries in using spacecraft to obtain and disseminate needed information.

I don't know the quality of the photos "Priroda" is supplying for export, but the Soviet user often receives complete junk that, in addition, is adorned, like a joke, with a restrictive stamp, which itself is often quite serious. What kind of availability of space information is Yuriy Pavlovich talking about? And when you can order a photo, admittedly not cheap, of almost any region on Earth (including the USSR) on the world market. Who are we hiding it from?

The USSR has a shelf area that no other country can match. Its oil and gas content has been proven. We still haven't found the key to this national wealth. Most of the shelf is inaccessible because of certain natural conditions: Ice fields cover it most the year, and temperatures are low. Space photos could, it seems, be an important aid in studying it. Our group at Voronezh University has developed engineering techniques which make it possible to judge the composition of bottom deposits in shallows with a certain confidence and to study the movements of the sea bottom. Individual areas of the sea have a tendencies to rise, others to sink. Information about this is useful in predicting oil and gas deposits. Ways have been discovered to conduct intelligent searches for deposits of valuable minerals on the sea bottom. Space can do this, too! Patents have been granted for new techniques associated with studying water areas. Special trials have confirmed the technologies' efficiency, and competent conferences have recommended that the advanced domestic experience be disseminated. Encouraged by these evaluations, we prepared a set of original maps of one socialist country's shelf that is very promising in terms of oil and gas content. One could have talked about the USSR selling the licensed product—a new Soviet technology (technique) and the results of its use. But the misunderstandings and obstacles began, and the press is full of such examples. "Space photos?!" they declared in surprise at the Ministry of the Gas Industry. "What kind of photos? From where? And they're American yet. Just our luck...."

So those licensed materials were developed using high-quality Landsat photos. After several years of discussions with "Priroda" State Center and other organizations, we couldn't get suitable domestic materials. Just don't think that the shuffling of the licensing papers would have been expedited if the studies had been done with Soviet space photos of the same resolution as Landsat. Just the opposite! It's incomprehensible, but the Soviet user only hypothetically has access to a domestic image even close to Landsat's in resolution. It's forbidden to show Soviet photos at open meetings or to freely use them for manufacturing or scientific purposes, to transport or discuss them. One might find some logic in the prohibitors' actions if we were a country that had a monopoly in photography from space. Or if were only us who we had photographed our territory from space. Or if no one else knew how to photograph like we do. But this is absolutely not the case—far from it! Even the procedure for placing orders for space materials does not stand up to criticism. State enterprises—whether a higher educational institution, a geological exploration expedition, or a powerful association seeking gas on the shelf—can't order photos directly from "Priroda." They can only request that their ministries petition the Main Administration for Geodesy and Cartography on their behalf. Naturally, ministries are in no hurry to fulfill these trivial requests—they have more important concerns. Space speeds exist only in orbit.

As a result of many years of concealment and restricted access to domestic space photos, good intelligent material obtained in space at huge costs, not to mention the risk to the lives of space researchers, has been compromised. I recall a typical scene. A Landsat photo of its steppe region was shown to the land department of an agricultural rayispolkom. The land managers and agronomists were interested. They could see forests and forest strips. Exclamations of recognition began to ring out. "There's Round Forest! That's Coal Forest. Look at how the gullies run....You know, we don't have many forest plantings. We should stick some there, and there...." One comrade was distraught, "How can you bring such things? Surely they're secret. You can't!"

I carefully explained that they couldn't be secret, we bought them from the imperialists. That, unfortunately, the USA sees more than the Round Forest on such photos of our country. But we were in their region on business—a geological expedition. The comrade didn't believe that everything was visible, usable, and allowed. Things like that don't happen in real life!

Fundamental changes are taking place in our life after the 27th CPSU Congress. Timid shifts are noticeable in "Priroda's" activity, too. For many years, the lucky ones received space materials for which they had properly completed the paperwork...for free! Under agreements on creative collaboration. With this kind of economic "incentive," indeed any movement for the public good brings a loss. Now, creaking, the economic levers are beginning to have an influence. Photos are now available

for a fee. However, things are far from ideal! The center is obligated to operate under self-accounting like any other production enterprise and produce a profit for the state.

Positive experience exists in the country. The Central Photogrammetry Enterprise of the "Aerogeologiya" Geological Production Association has operated on an economic basis from the very beginning. It provides any organization, regardless of departmental affiliation, with foreign space photos. This company, thank you, has always filled orders on time with good quality. It's a shame, though, that its stock is so small. It is to its (and all "Aerogeologiya's") credit that interest in practical work with remote materials still exists.

There is one more thing I would like to talk about. For many years, only two countries have photographed the planet from space, we and the USA. But the world market for space information was ceded without a fight to the Americans. Don't we need hard currency?

I talked with Chinese and Indian geologists at the 27th International Geological Congress. Only Landsat photos are used in work on the huge territories of these states (not to mention Canada, Australia, Brazil, etc.). They are acquired for many millions of dollars. Is one space photo, a little square of photographic paper measuring 23 x 23 cm expensive? I have in my hands the order blank for standard product already filled in for me, a potential buyer, by NASA's Regional Space Data Center in Sioux Falls, South Dakota. The form lists the numbers of the best (in their opinion) space photos of the Middle Don, with the price—$12 a print. Nobody sent me the cadasters and lists as "Priroda" unfailingly did a year or two after my request, "You need it, choose it yourself!" No red tape, no inquiries about how I plan to use the photos, where I'll keep them, to whom I'll show them! I have to send $96 for the eight prints selected for me, and the photos will be sent to any address indicated. This blank is from the year 1978. Space photos have gone up in price, but users have nowhere else to go, and they pay. It makes you want to shout, "But why are we, who were the first to point a camera's lens at the planet Earth, so backward and impractical?"

Finnmap Company, of Finland, has been successfully operating throughout the world since the end of the 70s. Dozens of governments use their services. Making extensive use of space photos (all Landsat's), Finnmap prepares maps for any inaccessible territory and surveys locations of engineered structures, from industrial combines to summer cottages. Now the company has acquired Soviet photos, although we're late in selling them—they'll be useful in the work, and they'll offset the costs!

A report has surfaced that the U.S. Geological Service is preparing to buy Soviet space photos. Why would they spend their money when they have their own satellites? For the same reason: more photos means more information. They have already praised us. The resolution of the Soviet materials is higher than that of Landsat. This is the first, very gratifying, but very, very timid sign of space commerce. Slowly, little by little, what has been sealed for so long is beginning to work for the country. After "overexposing" the photos, we have substantially devalued our bank of space data. Lars-Ulaf Sebbas, head of Finnmap, said of our cosmonauts' work, "The quality is outstanding, better than the Americans', but you're pretty late." If we don't move with the photos now, won't we end up like a certain rich man in the last century who planned to keep his millions in aluminum ingots, which were then costlier than gold?

On the state level, organizations developing new methods for studying space materials must be supported, and the system for providing remote photos to the national economy and to scientific institutes "below," in which practical problems are being solved, must be radically altered. Imported equipment for processing space images should be sensibly allocated on the basis of competition—to carry out projects that have a chance of making it to the foreign market. It seems that the departmental affiliation of the space data bank should be changed. It would be sensible and natural if the supplying of space materials to countries on a commercial basis were entrusted not to the Main Administration for Geodesy and Cartography, as it is now, but to USSR Glavkosmos [Main Space Administration], which produces the materials.

It would be good if the Main Administration for Geodesy and Cartography were to take the opportunity to convert the "Priroda" State Center into a domestic subsidiary of Finnmap, into a cost-accounting association with access to the domestic and foreign market and free of the distribution of space materials (of which "Priroda" is a user). That would change the organization's image for the better and objectively interest it in the results of its own work.

These measures should change for the better the strange situation that exists with the use of one of our society's outstanding achievements—space photography—which has been unavailable to the national economy for a quarter century.

IKI Scientist Scores Glavkosmos for Lack of Support to Space Science

WA18000709 Moscow PRAVDA in Russian 25 Mar 89 Second Edition p 3

[Article by K. Gringauz, head scientific associate of the Institute of Space Research of the USSR Academy of Sciences, winner of the Lenin and State Prizes of the USSR, and active member of the International Academy of Astronautics: "Loss of Escape Velocity"]

[Text] **One cannot say that the doubts the public has been recently expressing concerning the justification for expenditures on space research are groundless. TASS regularly**

reports on the launching of satellites of the "Cosmos" series "in order to continue research of outer space"; their number has exceeded 2,000. Our astronauts regularly float in weightlessness on the screens of our television sets. Soviet spacecraft regularly photograph Halley's comet and Mars' satellite from short distances.

Yet the newspaper's readers, having recently learned a mass of previously unavailable information (for example, about our country's Armed Forces), in spite of the apparent abundance of articles on the subject of space, are essentially very poorly informed about our space research and the work of the space industry. This is perhaps the only zone we have left that is beyond criticism (demands to reduce expenditures "on space" without any justification cannot be called criticism).

Let us clarify what we are speaking about. State funds are spent for space projects related to two types of research. First, applied—conducted in space for practical purposes (for example, photographing the earth's surface in various wavelengths in order to search for minerals, to estimate the future harvests, to study atmospheric processes, to search for schools of fish in the world oceans, to provide reliable radio and television communications on a global scale, to navigate ships in the sea, to create new materials under conditions of weightlessness, and so forth). Second, fundamental—that is, related to the study of space itself—the physical properties of the space surrounding the earth, the solar system, and the universe.

The first type of research interests a great number of departments. Many of them are profitable, and it is even possible to obtain convertible currency for the results of some of it.

But fundamental research interests mainly the Academy of Sciences. It does not receive support from the departments, and it does not produce an immediate advantage, although, as a rule, it serves as the basis for applied research.

One can say with confidence that appeals to economize "on space projects" strike a blow (and they already have) precisely to this type of science. This is the kind we shall be discussing.

Research using spacecraft has changed mankind's ideas both about the space surrounding the earth and about the universe. A mere 30 years ago it was thought, for example, that the earth's magnetic field, as the field of a permanent magnet, diminishes as the cube of the distance from the center of the earth, that is, very rapidly, and that at a distance of about several thousand kilometers from the earth's surface begins interplanetary space, on whose properties the earth's existence has no effect (not counting, of course, the field of gravity). But it turned out that the fields of plasma, continually emitted by the sun in all directions, interacting with the earth's magnetic field, draw out its lines of force in antisolar directions, thus creating an immense extended area with a diameter of approximately 200,000 km and a length of more than a million km, in which it is quite possible to measure earth's magnetic field. The discovery of this area (which can be called the magnetosphere and which reminds one of the tails of comets) was at first underestimated by astrophysicists. But subsequent observations from spacecraft showed that such structures are extremely widespread throughout the universe.

It became obvious that the study of astrophysics is impossible without spacecraft.

The first revolution in astronomy, associated with Galileo's telescope, took place in the 16th century. After World War II the second began—ground-based radio astronomy appeared. Then satellites made X-ray and gamma astronomy possible. Earth observations of very short electromagnetic waves irradiated by extraterrestrial sources are impossible because of absorption in the atmosphere. Astronomy became all-wave. The second revolution in astronomy changed in an extremely significant way the picture of the universe we had previously—the number of observed extraterrestrial sources of radiation increased many times over and the physical properties of many new sources turned out to be unexpected. This is not the place to enumerate all the scientific results achieved with the help of spacecraft, not to mention delving more deeply into their details, but it is obvious that they will be included in the "gold reserves" of knowledge that have enriched mankind.

But what price are we paying for our country's participation in the accumulation of this knowledge? Is the money we have invested in this being used effectively? First of all one should recall that in order to launch the first spacecraft, we used as carriers powerful ballistic missiles whose creation during the fifties was stimulated by defense needs. The country was (as it is now) surrounded by military bases with aircraft that carry nuclear weapons and our vital centers were within their range while the United States could not be reached by our weapons. The creation of powerful missiles required immense efforts from various branches of industry, and when they were created out of historical necessity, the expenditures on the development of satellites and interplanetary equipment launched with the help of these missiles comprised only a very small part of the overall expenditures.

What is the situation now? It was noted above that we have already launched more than 2,000 earth satellites of the "Cosmos" series. The newspaper readers are disturbed by the immense amounts of money spent by scientists. But the scientists have nothing to do with this. Specialists (both ours and foreign ones) know that in reality almost all these satellites are launched not for "investigation of outer space" but for applied purposes, in the interests of those departments mentioned above. It is easy to explain this when one looks, for example, at the complete sets of the journal KOSMICHESKIYE

ISSLEDOVANIYA [Space Research], which is published by the USSR Academy of Sciences and gives the results of the experiments conducted in the interests of space science, including on satellites of the "Cosmos" series. The number of satellites of this series on which these experiments were conducted can be counted on the fingers of one hand.

About 15 years ago satellites of the "AUOS" series were developed in order to investigate "near space" (i.e. altitudes from 220 to several thousand km). On these satellites Soviet scientists (in a number of cases, in conjunction with scientists of the socialist countries and France) conducted a number of physical experiments. Over the years the design and technical specifications of these satellites have become outdated and their production is being halted. Nonetheless several more will be launched in the next few years. Glavkosmos does not plan to design new and better satellites of this class although science needs them.

At the end of the sixties artificial earth satellites of the "Prognoz" series were developed for scientific research in orbits with great distances from the earth. "Prognoz-9," for example, was sent out approximately a million km. Since 1972 nine satellites of this series have been launched and two more are to be launched. The specifications of this equipment even 20 years ago did not go very far in satisfying the requirements for scientific research—in terms of precision of orientation, volume of information transmitted, or service life. Now, taking into account the development of equipment and technology over past decades, satellites of this series look like a complete anachronism. The market place does not offer consumers, for instance, cameras that were developed at the end of the sixties—since that time there have been several generations of new cameras. But Glavkosmos considers it possible to offer "Prognoz" to the Academy of Sciences again and to not develop a more modern satellite for similar purposes. Naturally, this offer cannot be accepted. Yet the space surrounding the earth (in which practical space exploration is mainly conducted) requires further study at a new scientific and technical level. In the space plans of the United States, Japan, and the European Space Agency (which combines the majority of European countries) for the next 6 years, an eminent place is occupied by the creation and launching of two systems of artificial earth satellites for studying the space surrounding the earth and solar-earth physics consisting of eight spaceships created using the latest technical achievements.

Modern space research for many reasons (including economic and political ones) is becoming more and more international in nature. The Soviet Union can participate in this international division of labor, naturally, by making the appropriate contribution, particularly by exchanging scientific information of a modern level. In order for space research on the area surrounding the earth not to come to a complete halt and to carry out international cooperation in this area, the Institute of Space Research of the USSR Academy of Sciences has decided on what I would call a desperate step: an attempt to create a satellite—A small space laboratory—through its own forces, through cooperation, without the participation of enterprises of Glavkosmos.

The only new type of spacecraft developed by industry in recent years for planetary research is the "Phobos" which was launched toward Mars in the middle of 1988 (the "Vega" spacecraft are modifications of the old stations of the "Venera" series). From the standpoint of setting up scientific experiments it has a number of shortcomings, it is difficult to properly install the necessary set of scientific instruments on it, the volume of scientific data transmitted is small, and the weight of the scientific equipment is small as compared to the weight of the entire structure.

These shortcomings are related to the incorrect interrelations between the Academy of Sciences and the space industry. Chief designer, Academician S. P. Korolev, knew well all the associates of the academic institutes who had set up experiments on spacecraft of his experimental design bureau; he conferred with them many times during the development; and his associates were physicists who had similar ideas—after all, they were solving common problems. The same style was exhibited by G. N. Babakin, to whom S. P. Korolev turned over the development of planetary craft from his own experimental design bureau. Korolev was vitally interested in the results of physics research and tried to encourage new experiments. We have now published the letter S. P. Korolev sent in 1959 to the Astronomy Council of the USSR Academy of Sciences in which he reproached our astronomers for their lack of proposals concerning extra-atmospheric astronomy; he himself went to the Shternberg Astronomy Institute of Moscow State University in order to stir up the initiative of the astronomers.

During the years of stagnation everything gradually changed. Now the Institute of Space Research is in the position of a junior partner (and almost without rights). Industry designers themselves determine the configuration of spacecraft, the specifications of its service systems, the weight and energy consumption of the scientific equipment, and then they offer it to the Institute of Space Research of the Academy of Sciences: If you want to, you can use it; if not, then don't, but there will be no other. One gets the impression that the fewer the experiments the scientists conceive the more satisfied the designers are—it is easier for them this way. The designers have no real interest in the results of scientific experiments that go beyond the limits of the understanding of the ordinary newspaper reader (television picture, chemical composition of the ground); they need results from experiments only for their reports. Let us note that the loss of the first spacecraft "Phobos" is in the same category and is explained by the same causes as the destruction of the steamer Admiral Nakhimov, i.e. it is related to the incompetence and irresponsibility of people and not to any technical errors. The Academy of

Sciences has to put up with this because it has no levers for influencing the industry that manufactures space equipment. Throughout the world scientific research institutes are clients and industrial enterprises are the providers; the former pay money and order what they need. In our country the Academy of Sciences does not have control of the funds used for the development and manufacture of spacecraft and they receive the equipment free of charge. Naturally, the producer dictates the conditions in this situation. If these funds were allotted to the Academy of Sciences and if the design bureaus of Glavkosmos were financially interested in filling the order, the technical level of Soviet spacecraft and their development on earth would undoubtedly improve sharply.

The total expenditures on fundamental research on outer space using unmanned spacecraft (including both expenditures on the craft themselves and their launching and expenditures on scientific instruments) are relatively small as compared to the overall expenditures on the space industry, and the savings on unmanned scientific projects would add little to the counters in our stores.

Why are unmanned spacecraft called the main means of investigation of outer space? What research can be conducted on the piloted craft "Mir" and "Buran"? At the present time the orbits of these vehicles run at altitudes of hundreds of kilometers where it is impossible to solve problems that can be solved with satellites of the "Prognoz" type that go as far as a million kilometers from the earth. Because of the existence of a unique "atmosphere" near the space ships, that is, their "vacuum impurity," they are also unsuitable for much research that can be conducted with automated satellites at lower altitudes.

It is possible to conduct astronomic observations on orbital space ships. The measurements taken by the astrophysical module "Kvant" which is attached to the station "Mir" have produced and still are producing highly interesting results. But the "Kvant" module uses from the "Mir" station only electric energy (it does not have its own solar batteries) and once a day during one passage of "Mir" around the earth the astronauts orient the complex in the way that is necessary for the telescopes. If the "Kvant" were an autonomous unpiloted satellite with solar batteries and orientation according to a set program and according to commands from the earth (which is technically quite possible), it could be put into an orbit where the overall time of its observation would increase sharply, thus increasing the effectiveness and output of the telescopes.

But the astronauts' program at the orbital station is so filled with various tasks and applied experiments that they have an insignificant amount of time left for astronomic observations (a couple of percentage points of the total time).

The development and implementation of the system "Energiya-Buran" entailed overcoming immense difficulties and they are an exciting engineering achievement. But it is precisely an engineering achievement. There is no justification for categorizing these expenditures as expenditures on fundamental scientific research conducted in our country, and it is not easy to answer the question of why we need this system at this particular time.

In our country it has been reported that because of the immense expenditures required for the development of reusable space ships of the "Shuttle" series the United States has significantly reduced its national program for scientific space research. The same thing (an essential reduction of the scientific space research program) has happened here. The difference is that with our country's lesser economic potential, we, who have a practically permanent orbital station with numerous expeditions and an efficient system for supplying the complex with the necessary cargoes (which the United States does not have), have created an additional system—"Energiya-Buran."

Rockets of the "Energiya" type can apparently be used not only for launching the "Buran" but also for sending men to Mars. But the beginning of these flights is planned for the year 2015, and in a quarter of a century the systems for control of the rocket and the sets of all the special equipment will undoubtedly become obsolete.

In my opinion, it cannot be ruled out that the main reason for the creation of the "Energiya-Buran" system was the desire of that branch to assert itself and not the real needs of the country and science.

At the international symposium in Moscow on the occasion of the 30th anniversary of the launching of the first satellite an impressive program for research on Mars was announced (for the next decade with the help of unmanned spacecraft). But its implementation is beginning with striking laxity. Thus we have not even begun to develop the scientific instruments for the spacecraft "Mars-94" (which is to be sent up in 1994—based on the design of the "Phobos" craft). Even though abroad they are intensively developing instruments intended to be sent up in 1995-1996 (the time period necessary for designing and developing on-board scientific instruments is now considered to be 5-6 years). Delay in the work on the design of the "Mars-94," which will lead to a deterioration of the quality of the research, is apparently of equally small concern to industry and to the presidium of the USSR Academy of Sciences.

All that has been said makes one think that a continuation of fundamental space research, which began brilliantly in our country, is causing deep concern at the present time, and the plans for creating spacecraft for scientific research and space ships must be significantly adjusted.

In the United States the budget and the programs for space research are discussed publicly and approved by the Senate. It would be wonderful if such a policy were introduced by the new USSR Supreme Soviet which will be elected this year.

USSR To Propose Global Space System for Ecological Monitoring

18660157 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 21 Feb 89 p 3

[Article by I. Baranovskiy, correspondent]

[Excerpt] The 26th session of the subcommittee on science and technology of the United Nations Committee on the Peaceful Uses of Outer Space will begin its work today in New York. Scientists will discuss how to use space technology more effectively for monitoring the environment. Before the Soviet delegation took off, our correspondent met with academician Oleg Georgiyevich Gazenko, head of the delegation, and Professor V. Akovetskiy, head of the Main Administration for Scientific-Technical Progress and Ecological Normatives of the USSR State Committee for Nature Conservation (Goskompriroda).

"Our scientists have prepared proposals in regard to creating a unified information system for ecological monitoring of the environment [said O. Gazenko]. This idea will be discussed in New York. But it would be better for Professor V. Akovetskiy to tell about it."

"Within the framework of the unified system, we plan to create two divisions—a global space system for ecological monitoring of the environment and a state system of ecological information," said Viktor Ivanovich. "The first division will have the task of gathering information, and the second division's task will be to process it quickly and effectively. We thus intend to install highly sensitive transducers at all dams and nuclear power stations in earthquake areas. In the event of an accident or the approach of a disaster, these devices will contact a satellite instantly and warn of trouble. We intend to use also remote-sensing equipment—video spectrometers, lidar units, multizonal scanners and microwave radiometers. With the aid of this equipment, we will obtain information on sources of environmental pollution, the scale on which harmful waste discharges spread, and the ways in which they spread. Cosmonauts will also take part in our programs."

"The idea is excellent, but to what extent can it be implemented?"

"It has already been discussed in USSR Goskompriroda and the USSR Academy of Science with the participation of representatives of the Main Administration for Development and Use of Space Technology for the Economy and Scientific Research, the Ministry of Geology, the State Forestry Committee and the Cosmonaut Training Center. The main points have been approved. Everything hinges on the financial aspects of the matter, since it will take four to five billion rubles to develop a unified system. But the economic benefit from preventing harm to nature will be about 25 billion rubles a year, according to specialists' calculations. We would like to believe that this idea will be supported also by our foreign colleagues at the session in New York. We wish to propose that a system of international joint enterprises, laboratories and ecological-instrument building centers be created. We are also thinking of putting the "KOSPAS—SARSAT" system to work warning of accidents at nuclear and hydroelectric power stations and at facilities which produce dangerous substances. After all, the future of our planet is involved."

FTD/SNAP

Recollections of Rocket Control Systems Designer N. A. Pilyugin

18660158 Moscow KRASNAYA ZVEZDA in Russian 25 Feb 89 p 4

[Article by M. Rebrov, Colonel]

[Abstract] The full-page article is one of a series on developers of the first Soviet ballistic and intercontinental missiles and space technology. The author traces the career of the late academician Nikolay Alekseyevich Pilyugin, a chief designer of space-rocket control systems. He was one of the six members of a council of design engineers which academician S. P. Korolev headed. Particular attention is devoted to Pilyugin's role in development and testing of self-contained flight control systems for the USSR's first space rockets, as well as control systems for launch-rockets and spacecraft which were subsequently developed.

Recollections of Pilyugin are shared by his wife and some of his former colleagues, including Valentin Konstantovich Krotov, a deputy chief designer in charge of flight tests whom the author of the article met at the Baykonur Cosmodrome. Krotov recalled that he once asked for a job with the design bureau of which Pilyugin became deputy head in 1947. Krotov was working for Korolev and Boris Yevseyevich Chertok at the time. Krotov subsequently worked at experimental plant NKO-1 on testing of control actuators which Korolev's design bureau and Chertok developed for R-1 rockets. Krotov recalls that he and Pilyugin were both at Baykonur for the first launch of a "Soyuz" spaceship in April of 1967, and that Pilyugin was severely shaken by the death of cosmonaut Volodya Komarov.

FTD/SNAP

Scientists at IKI Protest 'Undemocratic' Selection of Academy Candidates

18660159 Moscow PRAVDA in Russian 1 Feb 89 p 3

[Article by A. Pokrovskiy]

[Abstract] The article examines the validity of complaints made in a letter which a conference of science associates of the USSR Academy of Sciences' Institute of

Space Research (IKI) adopted on January 20, 1989. This letter is addressed to the electoral commissions of the government and the USSR Academy of Sciences and to the editors of the newspapers PRAVDA and IZVESTIYA. The letter criticizes a list of 23 scientists who have been selected as academy nominees for seats in the USSR Supreme Soviet. This list was adopted by a plenary session of the academy's presidium which took place on January 18. These nominations are protested on the grounds that the presidium did not follow democratic procedure in selecting the nominees; the opinion of almost half of the academy's associates was not taken into account, it is claimed, and the names of such eminent citizens as A. D. Sakharov, R. Z. Sagdeyev and T. I. Zaslavskaya are missing from the list.

The author of the article, who attended the January 18 session of the academy's presidium, recalls that more than 200 persons were present at this session, that procedures prescribed by the country's electoral laws were conscientiously observed, and that all remarks and motions made at the session were discussed and put to a vote. Participants of the session were given ample opportunity to become acquainted with prospective candidates. This is contrasted with the January 20 conference at IKI. According to the minutes of this meeting, only 236 of the institute's 1,420 personnel were authorized to take part in it, and only 210 of these associates attended the conference.

A meeting is recounted with two representatives of IKI, who answered questions about the conference's proceedings. They were Professor Vasiliy Ivanovich Moroz, a signer of the letter, and V. Linkin, a member of a group of initiators. V. M. Balebanov, deputy director of IKI, and Doctor of Physical-Mathematical Sciences V. V. Kerzhanovich were among the speakers at the conference, it is recalled. It was found that none of the conference's participants had attended the January 18 meeting of the academy's presidium. The scientists mentioned in the letter—Zaslavskaya, Sakharov and Sagdeyev—had either voluntarily withdrawn their candidacies or had been nominated from constituencies other than the academy.

The author concludes that the IKI letter's charges are unsupported by the available evidence, and that its authors may have been motivated simply by resentment of the fact that some of their own favorite candidates had been passed over for nominations.

FTD/SNAP

'Definite Military Element' in Discovery Mission

PM1603110189 Moscow IZVESTIYA in Russian 15 Mar 89 Morning Edition p 5

[Correspondent A. Shalnev report: "Discovery in Orbit"]

[Text] New York—Five astronauts, four rats, 34 chicken eggs, and a communications satellite. The latest shuttle, the Discovery, was launched into space Monday with this "crew." The launch, which was postponed for almost a month due to various types of technical faults, was almost aborted once again: It was hampered by a very thick fog over the Cape Canaveral launch center in Florida and very strong winds. But the fog dispersed, the winds died down, and the Discovery took off.

This is the first space shuttle expedition this year, and the third since NASA resumed its flights in the program interrupted by the loss of the Challenger in January 1986. There will be six more flights by December, with three of them—in July, August, and November—assigned entirely to the Pentagon. According to press reports, spy satellites will be launched into orbit during these secret expeditions.

A conventional satellite costing $100 million has been launched during the present expedition. Equipped with its own boosters, the satellite, which is intended to set up a stable communications link between space and earth, will be suspended above our planet at a height of about 22,000 miles.

If everything goes normally, the Discovery flight will end Saturday 18 March when the shuttle lands at Edwards Air Force Base in California. The 5 days of the expedition will be packed with experiments. As ABC-TV has reported, tiny openings have been drilled in the rats' claws so scientists can find out how bones heal in conditions of weightlessness, while the chicken eggs are the object of another experiment that should help give an idea of how the embryo develops in space conditions.

There is also a definite military element in the Discovery program: It is expected that there are to be experiments that, as THE WASHINGTON POST writes, "will assist SDI."

'Storm of Protest' Over Selection of Japanese Journalist For Space Flight

LD3103124189 Moscow TASS in English 1054 GMT 31 Mar 89

[Text] Moscow March 31 TASS—By TASS correspondent Ivan Ivanov:

The announcement that the first journalist in space will be Japanese has provoked a storm of protest from interested Soviet pressmen.

The decision to send the journalist on an eight-day flight in a Soviet spaceship in 1991 came years and years after the late Soviet rocketry designer Sergey Korolev agreed that allowing a correspondent to join professional cosmonauts in space would be a good idea.

The plan was, however, shelved after he died in 1966.

"The journalistic profession by itself involves competition," commented KOMSOMOLSKAYA PRAVDA columnist Yaroslav Golovanov. "I would welcome a Japanese colleague to become the first journalist in space—but in a Japanese spaceship. I would welcome an American on board a U.S. space shuttle.

"But why should the first reporter in space be a Japanese on board a Soviet spaceship and the Soviet orbiting station? There isn't even a grain of logic about this."

A PRAVDA correspondent, attempting to answer the question, had this explanation: "We draw our salaries in ordinary Soviet rubles and cannot pay for the flight in the convertible currency that Glavkosmos (the Soviet space agency) needs so badly".

Many journalists, however, agreed that "it is inadmissible to trade in the nation's prestige" and that it is a matter of pride for the country to be the first to have a journalist in space, and one riding a Soviet craft.

From television screens and newspaper pages, Soviet reporters have been appealing to the Cosmonaut Training Center and Glavkosmos these days to give a possibility to a Soviet journalist to fly to space first.

The world's first man, woman, doctor and engineer in space have all come from the Soviet Union. Why shouldn't the first journalist in orbit also be a Soviet national?

But perhaps there is a way out.

The agreement signed with Japanese TBS [Tokyo Broadcasting Service] television for its reporter to become a paying passenger on a Soviet space station does not, as far as is known, include a provision for the Japanese to become the world's first journalist in space. Whatever the outcome of the whole story, however, the cosmic barrier to correspondents is being lifted and this is another landmark event in the history of cosmonautics.

Benefits of Space Program Technology Viewed

PM1204125989 Moscow KRASNAYA ZVEZDA in Russian 30 Mar 89 First Edition p 3

[Article by Colonel M. Rebrov in response to readers' letter: "What Is To Happen to 'Buran'?"—first paragraph is readers' letter]

[Text] First the press, including the central press, lashed out at the U.S. "shuttle," and now unkind words can also be heard about "Buran".... Are we financing outer space too lavishly, perhaps we should slow down until we patch up the holes? And what is to happen to "Buran?"

G. Karevskaya, V. Pushkov, and others (a total of eight signatures)

One curious story to begin with. Michael Faraday, the well-known physicist and scientific worker, once read a lecture at London's Royal Institute and demonstrated an experiment. The scholar put a coil of wire near a magnet and showed that a scarcely noticeable electric current was generated in the coil.

"Professor, if such a weak current can occur, what significance can this have?"

"Madam," Faraday gallantly answered her, "Can you foretell a newborn baby's fate?"

"How much did you get for this discovery?" the lady was not embarrassed to ask.

"Nothing yet," the scientist smiled....

Incidentally, this is by the way so as to answer the readers' questions to a certain degree.

...The flight was delayed. The apologetic voice of the controller could be heard through the air terminus loudspeakers: "The takeoff has been postponed for 2 hours because of thick fog in Moscow." This was not the first postponement. Many passengers had been languishing at the airport for more than 24 hours, and no one believed that in 2 hours the aircraft would take off and set off on its journey.

I thought: What about "Buran?" There are no limitations for it where the weather is concerned. And after flying for many thousands of km above the clouds, in space, it returns to a given landing "point." The run along the concrete runway begins and ends perfectly. Next to the welcoming party. But what if there is some sudden failure, a drastic change in the weather, and the shuttle changes its approach course to this same runway and accomplishes everything planned, only from a different direction? In the rain, in the fog, in the middle of the night. Fantasy? No. Reality! If only Aeroflot aircraft were equipped with such clever automated systems....

Actually, is this really the only marvelous thing about space technology? It proves that it is not just anywhere but here in our very own country that construction materials are created which can work reliably in conditions of extremely low or very high temperatures. We have at our disposal our own Soviet-produced durable [mnogoresursnyye] units and appliances, highly sensitive miniature instruments, the most powerful engine equipment, solar energy, and the most precise navigation systems...the list could be endless. Behind all this, among other things, are the technologies which have been mastered. It is not enough to call them modern, they are mostly unique, if we are talking about the precision, cleanliness, and quality of the goods produced. If only all this could be introduced into the national economy!

How much design talent has been invested in this work, how many scientific thoughts and ideas have been concentrated in it! What high professional skill has been required of those performing at the machine tools and production units—technologists, laboratory workers, programmers, analysts, workers! And how much of our national pride lies behind all this space activity!

If we are going to be absolutely objective, it should be recognized (because the whole world recognizes this) that in all these years the space industry has proceeded along nontraditional lines, established principally new technical solutions, and utilized only Soviet-produced equipment and materials.

"How much expenditure—simply money—went into creating 'Energiya' and 'Buran?'" Those accustomed to measuring everything only in rubles will ask this. A great deal! And no one is concealing this. It is silly to conceal it. Billions. If the expenses for the entire space era are added together, then it is many tens of billions, which to some degree, it is true, have lost their true cost in rubles. And the return? In rubles again? It is also great. Great, but it could be more. And this is also an undoubted fact. Undoubted and unfortunate. We should know how to count our money.

But I cannot fail to say something else. Clear-cut adherence to the customary categories, including matters concerning science and technology, sometimes distinguishes our attitude toward the world. The Tokamak proton synchrotron, a device for searching for "charmed" particles, a new space craft, and a super computer.... "Probably something important in keeping with the times," some people say with a shrug. And because official information on expenditure is scanty, "unofficial" information fills the vacuum. And immediately a certain psychological irritation disturbs the consciousness, forces out logic, and produces a vexing sense of personal frustration. Judgments become harsher: "They are complicating matters, they are throwing money away, they are not looking after the people's money." And one hears the alarmed call: "Down with outer space!"

I am not going to argue: We each have enough worries. Both our own and other people's. Both high-flown ones, so to speak, and earthly, everyday ones. Today's worries and future ones.

That is all so....

Incidentally, about the Americans. They are a practical, businesslike people who can count money and they not only live for the present but also predict their future. I know this from my own experience. I have been in that country three times and have become acquainted with its scientific institutes, the work of the National Aeronautics and Space Administration [NASA], and the space centers. I have heard flattering opinions about our space technology from most authoritative scientists. They are not compliments but specialists' opinions.

"The long-term 'Salyut' and 'Mir' orbital stations have enabled the Russians to find the best way to combine basic and applied research...."

"'Energiya' has 10 times more power than any Soviet vehicle, and four times more capacity than the U.S. reusable 'Shuttle' craft...."

"Achievements in the sphere of software and comprehensive utilization of sophisticated automated systems have enabled the Russians to resolve brilliantly a most difficult task—to implement the automated launch and return to a given point on earth of the reusable 'Buran' craft...."

These are not my words. It is "they" who are talking and writing about this. But I am not going to simplify the problem.

For many years space science and technology in our country have been closed to the public to a significant degree. In my view, this can be explained quite simply: The space industry emerged and developed on a defense basis. And those matters connected with the fatherland's defense are naturally not to be publicized widely. And the "cold war" years, nuclear blackmail, and the threat of a "hot conflict" also forced us to be reticent.

The secrecy also gave rise to certain mythical notions about our fundamental science, including space science. Many people think that we are unstinting in spending money on these spheres and we get no return. Is that so?

Figures are the best argument. So: Our expenditure on fundamental research (it is fundamental science which is the source of new knowledge and of the discovery of new phenomena and principles which bring about revolutionary transformations in society's economic and social life) is approximately 40 times less than in advanced capitalist countries. Concerning prestige, it is important here to explain the following point. Scientific development is not a linear process. It consists of alternating intermittent revolutionary changes. There can be no eternal leaders: neither in physics, nor in biology, nor in cosmonautics.

I hope one more "Faraday-type" digression will not seem strange. What would happen today if (let us suppose) we were suddenly deprived of electricity? If there is no current—that means that there are no lights, no assembly lines, cybernetic machinery is "resting," automated systems are "on strike," electric pumps, which send water to our homes, do not work, food stocks are spoiled as the refrigerators fail to "maintain" the necessary temperature. There are no communications—television screens are not working, trolley buses and electric trains stand idle.

But what if we hypothesized another situation? For example, there are no communications satellites or other form of space technology. People would be deprived of such important elements in their lives as long-range communications, meteorology, navigation, geodesy, geology, accounting of reservoirs and sown areas, cartography, environmental monitoring.... All this is taken not in a broad sense, but taking account of economic expediency. Unfortunately, it is difficult to cite complete figures here, for the economic result received from automated apparatus and manned systems working in orbit is scattered around many ministries and departments. But such figures do exist.

A few examples by way of illustration. Let us take satellite navigation means. Their utilization on large-capacity ships makes it possible to save from R80,000 to R100,000 per annum. Now more than 3,000 of our ships with a tonnage of 100 registered tonnes and over are equipped with satellite navigation instruments. Environmental monitoring from outer space provides a revenue of R12-17 for every ruble spent. Precise weather forecasting for 5 days in advance is capable (if people are active and not sluggish) of saving agriculture R5-6 billion. Production in orbit of new materials with set characteristics (crystals, alloys, compounds, medicinal preparations, extremely pure materials and so on) are capable of producing a profit of R5-50 billion in the next 5 years. One photograph from outer space covers 200 square km of the earth's surface (one exposure covers the whole area of the Azov Sea.) Yet before the last quarter of our century only 13 percent of the territories of our planet's continents were photographed on a scale 1:25000 or larger. And what about the commercial activity of the Main Administration for the Creation and Utilization of Space Technology! If we are going to refer to the Americans, I shall say: Some 3-4 times more money is assigned for space research within the NASA framework than in our country.

And one more thing. Do we have the right to reproach the inventor simply because his creation—necessary and useful, promising great economic results for everyone—is not being broadly introduced into our life? Not by him but by others? Are things getting nowhere here because of bureacracy which is still alive and kicking? I would like to stress that our self-awareness is increasing in the reasonable and strict approach to everything that is now being done in the country. We must all think about the place of cosmonautics in the statewide system, have an active life stance regarding everything that concerns scientific and technical progress, and pay strict attention to the needs of life itself.

There cannot be two opinions about the fact that today, as never before, we need ideas—scientific, engineering, design, and technological ones—about technical policy in space. But this must not be wholesale criticism (incidentally, the space era is a little more than 30 years old), but profound interest in strengthening ties between space science and technology and production on earth. Interest in stepping up the pace of the introduction into earthly affairs of everything that cosmonautics gives and can give us. Space precision and space reliability must be the standard for many of earth's instruments, appliances, and systems. But not of themselves—but with our participation.

The intellectual power of "space" plants, scientific research institutes, and design bureaus promises the most enormous gains if it is reasonably and fully utilized. I repeat the main point: It is not one particular person's concern, but our common concern. The state's concern!

As for "Buran," it must fly.

Openness Concerning Space Costs, Benefits Urged

LD1204192989 Moscow Domestic Service in Russian 1700 GMT 12 Apr 89

[Text] A solemn soiree devoted to the Day of Cosmonautics was held in Moscow today. Academician Mikhail Fedorovich Reshetnev, hero of socialist labor, spoke at the meeting about the latest achievements of Soviet cosmonautics and its problems. He said, among other things:

[Begin recording] The "Energiya-Buran" reusable space transportation system has been developed on the basis of the latest achievements in our rocket construction and cosmonautics thanks to the work of numerous research and academic institutes, design and production organizations, and enterprises. It opens broad opportunities for conducting, at a qualitatively new level, both applied and fundamental space studies. Of course, this system has cost our country dearly. That is why it is important now to organize the speediest implementation of the new developments, materials, technical solutions, and technologies used in the "Energiya-Buran" system in the national economy in order to make up for the expenses entailed by its development.

The U.S. experience is instructive on this issue. It has been reported in the press, for instance, that the United States spent $24 billion on the lunar program while its industry had earned about $300 billion from space patents. By using the media, they managed to show the best side of their commodity and to suggest to their partners how and when to use profitably the technical advances developed during the implementation of the lunar program. Even at the viewing areas of launch pads, paid seats for spectators were ensured over there. But in our country everything is totally different. It is not the case that cosmonautics does not want, or is unable, to justify the funds allocated to it. Our main misfortune is our inability to earn profits. And this, regrettably, is characteristic not only of cosmonautics but also of a number of other branches of the national economy.

Pronouncements have been voiced of late which question the expediency of developing many space projects at the current stage of restructuring when the country is solving great problems, such as ecological, food, housing and others, which require huge material expenses. I think that such pronouncements are caused by insufficient information available to our public about the ways cosmonautics have been developing, its priorities, and about the potential of its achievement for the national economy.

This can be explained, to a considerable degree, by the fact that space science and technology have been created on the basis of advances in defense industries and rocket technology, which, naturally, were classified. This can be explained but cannot be justified. People want to know how and for what national funds are being spent and what results it yields. I am sure that if they had been told that in 1988 the economic effect of applied branches of cosmonautics had exceeded the total annual spending on cosmonautics by a third approximately, there would have been considerably fewer pronouncements of that kind. Cosmonautics is now approaching self-recouping. [end recording]

Figures Cited For Investment in Space Program, Returns to Economy

LD1304181289 Moscow TASS in English 1723 GMT 13 Apr 89

[Text] Moscow April 13 TASS—Last year 1,343 million roubles from the state budget were spent in the USSR on space research in the interests of the national economy and science, said Boris Chertok, a corresponding member of the USSR Academy of Sciences.

Speaking at the academy's general meeting which ended here today, he said that incomes from satellite communications services, weather forecasting, the exploration of terrestrial natural resources, satellite navigation systems, and the transfer of technology to the national economy amounted to about 2,000 million roubles in 1988.

Demands to slash expenditures on space research and to use the funds thus released for solving food, housing and other urgent problems were put forward in the Soviet press as well as in the election programs of many candidates for the posts of people's deputies of late.

In this connection Boris Chertok emphasised that such pronouncements were prompted by the lack of information among the public about ways of the development of cosmonautics and the possibilities for using its achievements in the national economy.

"Close interrelationships developed between academic science, institutions of higher learning and governmental agencies way back in the first years of the space era in the Soviet Union. Due to that a successful development of cosmonautics became possible", Chertok said.

"Space research performed the role of 'locomotive' which was blazing the way for other sectors. Were it not for cosmonautics, our lag is such fields as computing engineering would have been much greater than now".

Chertok said that one may well argue about prospects for the use of the Energiya-Buran space rocket transportation system but one should not forget the benefits of it to the national economy. Specifically, the system of landing on radio signals and cryogenic technology will be used in civil aviation while multiple-duplication safety systems will be applied in nuclear power engineering.

The unique stock of more than 700 packages of programs for computers of various classes which were used in the designing of the spacecraft are a national asset, too.

Benefits From Space Program Highlighted

PM1704104389 Moscow PRAVDA in Russian 13 Apr 89 Second Edition p 2

[TASS report: "Cosmonautics: Time of Renewal"]

[Text] The ceremonial meeting devoted to Cosmonautics Day which was held 12 April at the Central Academy Theater of the Soviet Army was attended by scientists, designers, Soviet cosmodrome workers, specialists from the cosmonaut training center and the mission control center, USSR pilot-cosmonauts, and representatives of the public.

Academician M.F. Reshetnev delivered a report at the meeting.

During a, in historical terms, relatively short period of time, our cosmonautics has achieved outstanding successes, he said. First and foremost among the events of the past year the speaker cited the successful flight of the "Energiya-Buran" system which took place in automatic mode from takeoff to landing. Another glorious chapter of the year was the year-long flight by Soviet cosmonauts Vladimir Titov and Musa Manarov on the "Mir" orbital complex—the first such flight in history. Three expeditions to this station with a Bulgarian, an Afghan, and a French citizen were also carried out.

The rapid development of space technology is a powerful stimulus to the advancement of machine building, electronics, power engineering, and other sectors of industry. This is why, the speaker stressed, we now face the task of putting the achievements of cosmonautics to more effective use in the interests of the national economy. At the same time, he said, the doubts that have been expressed by the public of late as to the expediency of expenditures on space research indicate that, despite the apparent abundance of publications about space research, our country's working people are essentially inadequately informed about its results, about what space technology is producing for the country's national economy today, and what it may produce tomorrow.

In this context the scientist cited interesting but little known facts which testify to the effectiveness of the utilization of various space achievements. Communications satellites are the undisputed leader in this respect, he said.

Telephone, telegraph, and facsimile communications, radio and television broadcasting, transmission of diverse information and other material, exchange of information in large automated control systems and computer networks, the transmission of matrices for newspaper publication—this is by no means the full list of tasks carried out in our time by satellite communication technology. The Moskva and Ekran system have made it possible to extend television broadcasting to 93 percent of the population. According to USSR Ministry of Communications information, the economic gain derived from the operation of the Orbita, Moskva, and Ekran systems totaled R540 million last year.

The operational Tsikada system makes it possible for an unlimited number of ships to ascertain their location with an accuracy down to 100 meters with the help of satellites of the "Cosmos-1000" type. This substantially enhances the efficiency of the utilization of the Soviet merchant fleet. Now more than 3,000 of our ships are fitted with this equipment.

The COSPAS system, which is based on the Tsikada satellites fitted with additional special apparatus for the detection of ships and aircraft in distress and the accurate determination of their coordinates, has been created. Together with the U.S.-French-Canadian SARSAT [Search and Rescue Satellite-Aided Tracking] system it forms a coordinated unified search and rescue service which has already saved more than 1,700 lives.

Long-term and reliable weather forecasting is of tremendous importance for the national economy. Since 1967 the Meteor meteorological system has been in service in our country. Its satellites are fitted with television and infrared equipment which makes possible the study of the atmosphere and earth and ocean surfaces. Meteorological forecasts enable us to substantially reduce potential damage to the national economy from natural disasters. This is helping to save between R500-700 million annually right now.

Space-based natural science has achieved great successes in the sphere of the exploration and development of natural resources. Satellite information is now being supplied to more than 900 organizations under the jurisdiction of various ministries and departments. The comprehensive exploration of natural resources from space is highly effective and brings in R350 million a year. The study of the natural resource potential of the earth from space, the speaker said, is closely tied up with the interests of each and everyone and provides a good opportunity for international cooperation. This is why the world public received with interest M.S. Gorbachev's proposal to set up a center for emergency ecological assistance at the United Nations.

Dwelling on the impact of space technology and engineering on progress in various spheres of the national economy, the scientist noted that because of them, aluminum and heat-resistant alloys and ceramic materials have been substantially improved and new methods of tungsten, beryllium, and molybdenum production have been mastered. New structural materials based on aluminum and titanium alloys reinforced with boron and silicon carbide fibers, carbon plastics based on graphite and polymer bonds, heat-reflecting carbon-carbon compositions, and thermoregulating coatings look to have a very promising future.

Experiments studying the possibility of the production of new materials in space conditions and obtaining large pure monocrystals, superconducting alloys, and superpure medical and biological preparations are of great importance for the national economy. According to specialists' estimates, revenue from the production of semiconductors and medical preparations in space may reach R20 billion by the year 2000.

Experiments to test technological processes for obtaining new substances and materials are regularly carried out in our country, both on manned space stations and on the "Photon" automatic craft. The first such craft was put into orbit 14 April 1988. The results of this work are beginning to be used in the interests of the national economy. For instance, the production of experimental models of electronic equipment using semiconductor materials smelted in space furnaces has begun. USSR Ministry of Health clinics are producing highly effective vaccines based on superpure pharmaceutical substances obtained in space. It is planned to increase the volume of Soviet medicines, biological preparations, semiconductors, and other materials produced in space to R3-R5 billion per annum by 1995.

The speaker then reviewed the path covered in 28 years of Soviet manned space travel. He emphasized that the Soviet Union has chosen the creation of permanent manned orbital complexes as the main sphere of the development of near-earth space and had achieved considerable success in this field. At present, the "Mir" complex has fulfilled all the set tasks and a new stage in its exploitation is beginning.

The speaker emphasized the need for the swiftest possible introduction into production of the new developments, materials, technical solutions, and technologies used in the "Energiya-Buran" system. In this respect, he said, U.S. experience provides an object lesson. According to the press the United States spent $24 billion on the "Apollo" program. At the same time U.S. industry made around $300 billion on space patents.

Our main problem, the speaker said, is that we do not know how to convert developments into profit, and that, unfortunately, does not apply just to cosmonautics but also to a number of other national economic sectors. Therefore, establishing an effective system for the utilization of our scientific and practical achievements is a priority task.

The elaboration of new space projects must take place on a sound commercial basis, the speaker said. Developing this thought, he emphasized that there have been many statements of late which question the expediency of the implementation of a number of space projects at the current stage of restructuring, when problems such as the ecological, food, and housing problems, which involve great expenditure, are being tackled. It seems to me, the scientist said, that these statements are based on the low level of our public's information about the development of cosmonautics, priority avenues in this sphere, and the potential for the utilization of its achievements in the national economy. If people were aware that the total economic gain derived from applied cosmonautics last year exceeded by approximately 50 percent its total expenditure, there would be substantially fewer statements to this effect.

In conclusion Academician M.F. Reshetnev focused attention on the problems confronting cosmonautics today.

The meeting participants warmly received a message of cordial congratulations on the holiday transmitted from the "Mir" station by A. Volkov, S. Krikalev, and V. Polyakov.

The meeting was attended by O.S. Belyakov, chief of a CPSU Central Committee department; leaders of a number of ministries and departments and the USSR Academy of Sciences; and representatives of party and soviet organizations.

Secrecy Blamed For Lack of Support For Space Program

18660160 Moscow TRUD in Russian
12 Apr 89 pp 1,4

[Vitaliy Golobachev article: "What We Are Finding, What We Are Losing"]

[Text] Yuriy Gagarin's 1 and ½ hour space flight around the earth was truly a breakthrough to the future. When I recall those bustling, beautiful days when people danced and sang in the streets, I also think of the great road that mankind has traversed to the stars and the complicated problems that have been encountered on that road. Not just technical problems. There has been a noticeable change in public opinion on space research. The letters to the editor testify convincingly to this. We have in recent times received only a dozen or so letters supporting the space programs and more than 100 demanding a sharp cutback in allocations for these programs; some readers are also suggesting that this research be halted completely.

There is just one argument: "What do we need with space if in the country we do not have sufficient means for priority needs here on earth and if millions of people are living below the poverty line and cannot even make ends meet?" The not so numerous proponents of developing the space programs answer thus: "Given our scandalous mismanagement, which costs the country many tens of billions of rubles, the amounts saved from the space program will not be enough to save the situation and would deprive us of our leading positions in a most important field and deprive us of our landmarks in the latest equipment and technology. As a result the country would be thrown backward and this would ultimately lead not to the saving of resources but to even greater spending—progressive lagging would cost the people dearly."

Who is right? Evidently both sides have arguments. But in my opinion, there is another more important question: Why has public opinion changed so sharply? Of course, the ecstatic enthusiasm was natural in the early years and could not continue forever. But why has it not been replaced by a calm interest in the exploration of space but rather the start of a skeptical attitude toward this important sphere to which, I am personally convinced, the future of mankind is one way or another linked?

I think that one of the reasons is a lack of information for our people and a lack of the data that would enable them to make knowledgeable judgments about things and judge the advisability of particular space programs as short-term or long-term goals, and the costs of such programs and the expected return from them (both in rubles and in the development of fundamental research), what degree of risk is entailed and so forth. A veil of secrecy has separated this sphere from the people, resulting in much more harm than might appear at first glance.

In our press the difficult and dangerous road into space, a road that demands true heroism and courage, has often been depicted as a smooth highway leading from one victory to the next. Even when dramatic complications have occurred along this "victorious" road we have tried not to talk too much about them. This kind of propaganda has not only failed to instill trust but, on the contrary, has distanced people from this sphere and deprived them of any sense of involvement....

And certainly it was not the journalists who were to blame for the fact that spaceflights seemed as easy as going out for a walk (not counting recent years): up into orbit, everything is very simply done, the return to earth, the awards are given out.... But it is a very rare flight that goes off, as they say, without hitches and problems.

Behind the veil of secrecy was also hidden the courage shown in emergency situations by cosmonauts, and their shortcomings, and the mistakes of the experts—the designers, controllers, the people who prepared the equipment....

A cosmonaut takes a shower on the station, catches a cold, which is exacerbated by the cold air from the ventilators, and the physicians initiate a course of treatment.... What is secret here? How can telling about this event weaken our power?

There have been more serious events: The fire on the "Salyut-6," for example, which, true, was extinguished by Yu. Romanenko and G. Grechko right at the start when the first smoke appeared. Or the fire on a rocket right before its launch. It was precisely then that the capsule with cosmonauts V. Titov and G. Strekalov was "separated" in emergency regime from the rocket by the autonomous solid-fuel engines (located at the top), launched upward and sheered off to the side, after which the capsule landed on its parachute right there at Baykonur. Or the accident when a space vehicle was being inserted into orbit, when the third stage had not separated and during the uncalculated ballistic descent V. Lazarev and O. Makarov experienced unprecedented G-loads that would have been fatal for any untrained person.... We learned the details of this only some time after the event, but how many other facts from the history of cosmonautics remain "out of the picture?"

But these are details, even though important ones. Today we do not know the main thing: how much is spent each year on space research (hundreds of millions? billions?) and what the return is. Discussion of the size of allocations in the USSR Supreme Soviet and extensive glasnost in this matter would, I think, make it possible to change public opinion precisely in favor of the development of cosmonautics. But with one indispensable condition, namely, that its achievements be used extensively in the national economy. Knowing the true state of affairs the public would be able to ask: Why are many of the materials from space photography of the country's territory not being used by our experts? Or why are new technologies worked on during development of "Buran" not finding application in the national economy? (I remember that the cost of the American "Apollo" lunar program, which amounted to several tens of billions of dollars, was recouped a hundredfold through the use of technical innovations in the economy). Why is it taking so long to develop a microfactory for operation in orbit—a technological module in which it will be possible to obtain unique materials for radioelectronics and other sectors?

I think that being aware of the complete picture would makes things not just a matter of some mechanical cutbacks in allocations for the space programs but of the most rational use of allocations and of bringing other sectors up to the level of the space sector.

And of course, the debate should be about more efficient use of the possibilities of the space fleet in the foreign market. By launching foreign astronauts and various kinds of satellites on a commercial basis and selling space photographs (if the quality is good the prices are very acceptable—thousands of dollars per photograph), we should generate foreign exchange more actively. In my opinion we should only welcome the latest steps taken by Glavkosmos in this direction, including the agreement with the Japanese TBS [Television Broadcasting Service] Company for a flight for a Japanese journalist.

There are also other Glavkosmos initiatives worthy of attention. The American journalist F. Vreyzo has described one of them in the PHILADELPHIA INQUIRER. The article is so interesting that it is worth describing it in some detail. F. Vreyzo reported on the lawyer Art Dyuel, a successful law professor who has an office in Houston. He has become the trade representative in the United States for the USSR commercial space fleet. Art Dyuel's task is to convince American companies to launch American satellites from the territory of the Soviet Union using Soviet launch vehicles.

"Like any good dealer," F. Vreyzo writes, "Dyuel can offer low prices—so low that they threaten to cut the ground from under the feet of competing private rocket-building companies in the United States. Moreover, he is promising that the Soviets can cope admirably with this task....

"The fact that the Soviets now have a man in the United States trying to sell Soviet space rockets testifies eloquently to the present reputation of America in space—in a word it is damaged.

"People at NASA and virtually all the experts unanimously think that the main reason for this is that several years ago this U.S. agency made a fatal mistake when it decided to abandon the use of single-use rocket launch vehicles and switched virtually all commercial, military, and scientific payloads to the reusable space vehicle that was put into service in 1981....

"On 28 January 1986 the Challenger blew up shortly after its launch. And suddenly America discovered that there was virtually no single-use launch vehicle to carry on the space shuttle program, but that there was a long line of payloads to be launched into space, including many commercial satellites that somehow had to be put into space."

However, the journalist continues, the commercial payloads could not wait forever. By that time the Europeans had their own "Ariane" rocket and they grabbed a good proportion of the orders.

The American rocket builders, encouraged by the U.S. Government decision to cut back in the future the total volume of commercial payloads on the reusable vehicles,

set about attracting clients for the new single-use rockets that they planned to sell directly to private individuals and to carry out the launches from launch sites rented from the government.

But before this actually happened the Soviet experts got into the game. They turned for help to people like Dyuel and his partner William Wayrin, a retired Air Force colonel. People working at the new USSR civilian space administration—Glavkosmos—behaved no better than capitalists greedy for money....

"The prices? No problem," Vreyzo writes. "There are reports that the Soviets are proposing to launch communications satellites and other payloads for about $20 million—less than half as much as the cost of using any of the new American commercial rockets....

"Some people are simply indignant at what Dyuel is doing. But not everyone thinks that launches with Soviet rocket launchers is such a bad idea. Two leading American companies—General Electric and Hughes Aircraft—also think that perhaps it is not so bad to launch communications satellites using Soviet rockets. But when they went to U.S. Government officials to explain the possibilities of doing this, the State Department announced categorically that such missions were banned."

Dyuel is hoping to convince the State Department to change this ruling. If he is not successful he proposes launching Soviet launch vehicles and American satellites in Australia....

The article by the American journalist is interesting not only because it talks about an unusual sphere of foreign economic business but also because it shows (even though on the basis of a local fact) what underestimation of the space programs can lead to. Of course, skeptics may say that we shall not die without this foreign market. Probably we will not. But the fact that we are lagging behind cannot be disputed. And lagging behind in world development means a loss of competitiveness in other spheres also, loss of foreign exchange, and enormous economic damage.... This is why, in my opinion, the space programs are necessary for us, but on sensible scales. They must be effective, and most important of all, drawn up and implemented publicly under the control of the USSR Supreme Soviet.

I understand that the ideas expressed here are certainly debatable and that this article is not a red-letter event and is different from those usually published on 12 April. But times have changed and they now demand directness, a businesslike approach, and the truth.

There is one graphic example that I would like to cite in conclusion. A lively debate is now under way regarding our immediate space plans. It was reported earlier in TRUD that after the completion late in April of the orbital shift of the "Mir" space station, A. Volkov, S. Krikalev, and V. Polyakov will be replaced by a new crew. But in these past days other proposals have been made. It is planned to dock new modules with the orbital complex only at the end of the year. Because of this, is it expedient to send a new crew to the station? What is more efficient economically—to abandon some of the experiments on the station and conduct others in unmanned regime so that when the new modules have been established on the "Mir" station crews can use them, or still send cosmonauts to continue the watch? Careful analysis make it possible to find the answer. But in and of itself posing the question in this way testifies to the fundamentally new approaches to spaceflight. And the fact that it is possible to conduct these debates openly in a newspaper when previously they were considered to be top secret is also a living sign of restructuring.

Of course, the problems that have been raised affect not only cosmonautics itself but all sectors of our industry. In the period of stagnation the unjustified secrecy (as opposed to any real need for it) and the tactics of silence and the use of half-truths instead of complete information were considered perfectly normal phenomena. So that cosmonautics is but one example of specific manifestations of secrecy in various spheres of our life. And the problems that we have been discussing should be resolved in the spirit of glasnost not only in cosmonautics....

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